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AMERICAN MACHINIST

A PRACTICAL JOURNAL OF MACHINE CONSTRUCTION.

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY.

Vol. 31. 505 PEARL STREET, NEW YORK. No. 9

Index to Advertisers and Classified Index Following Reading Matter.

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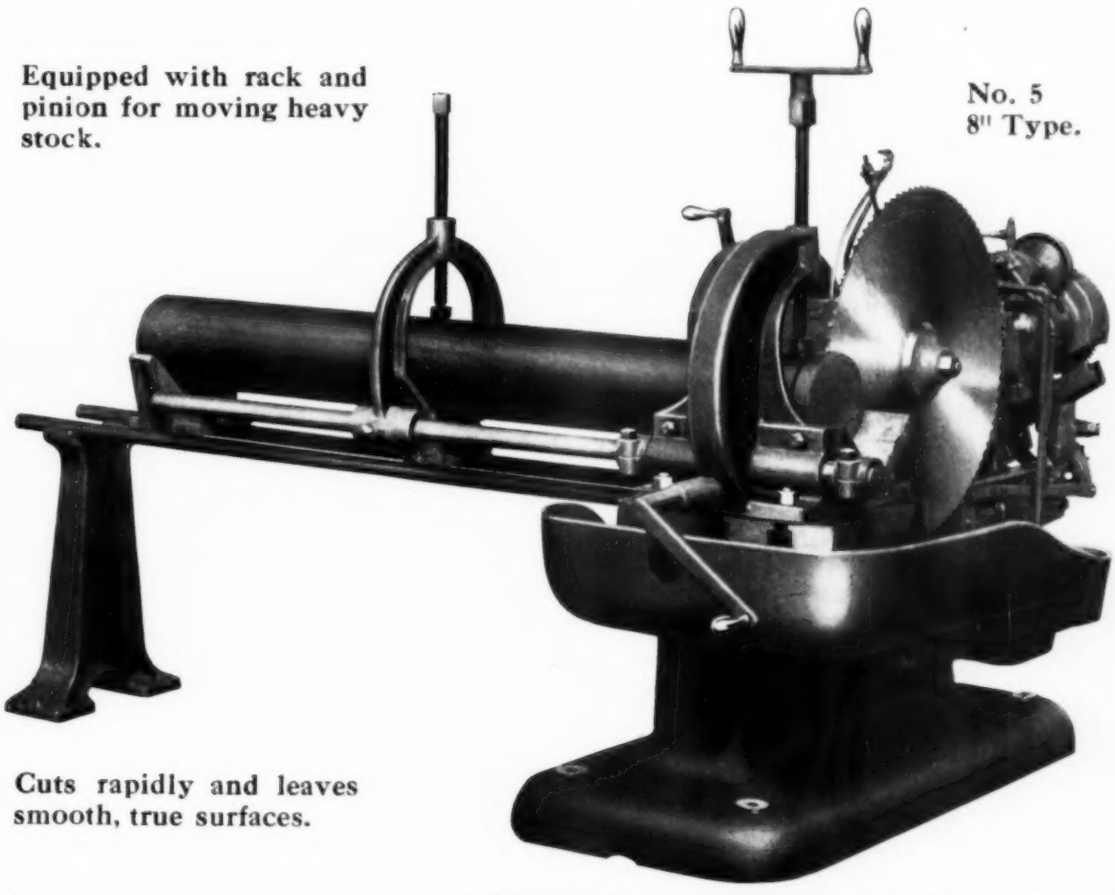

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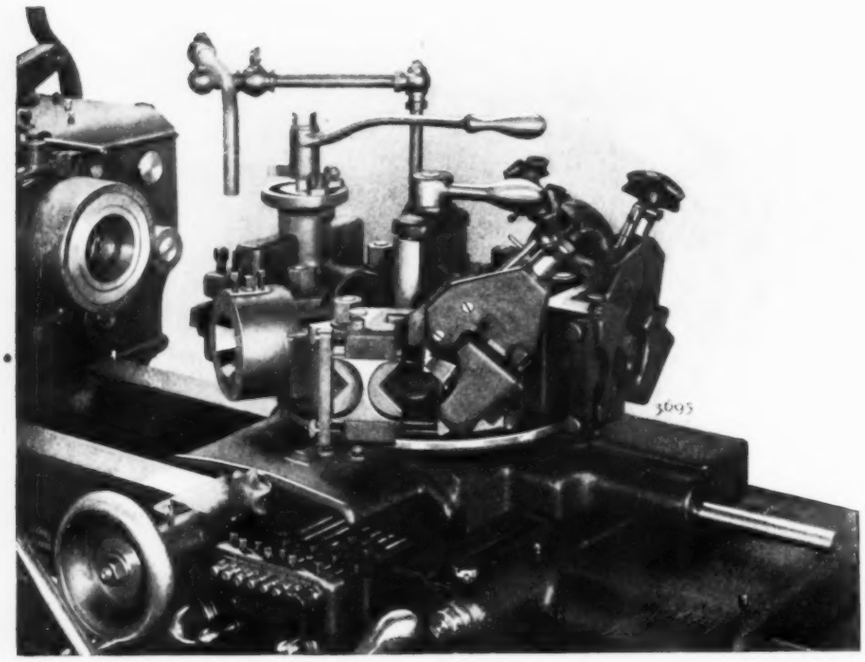

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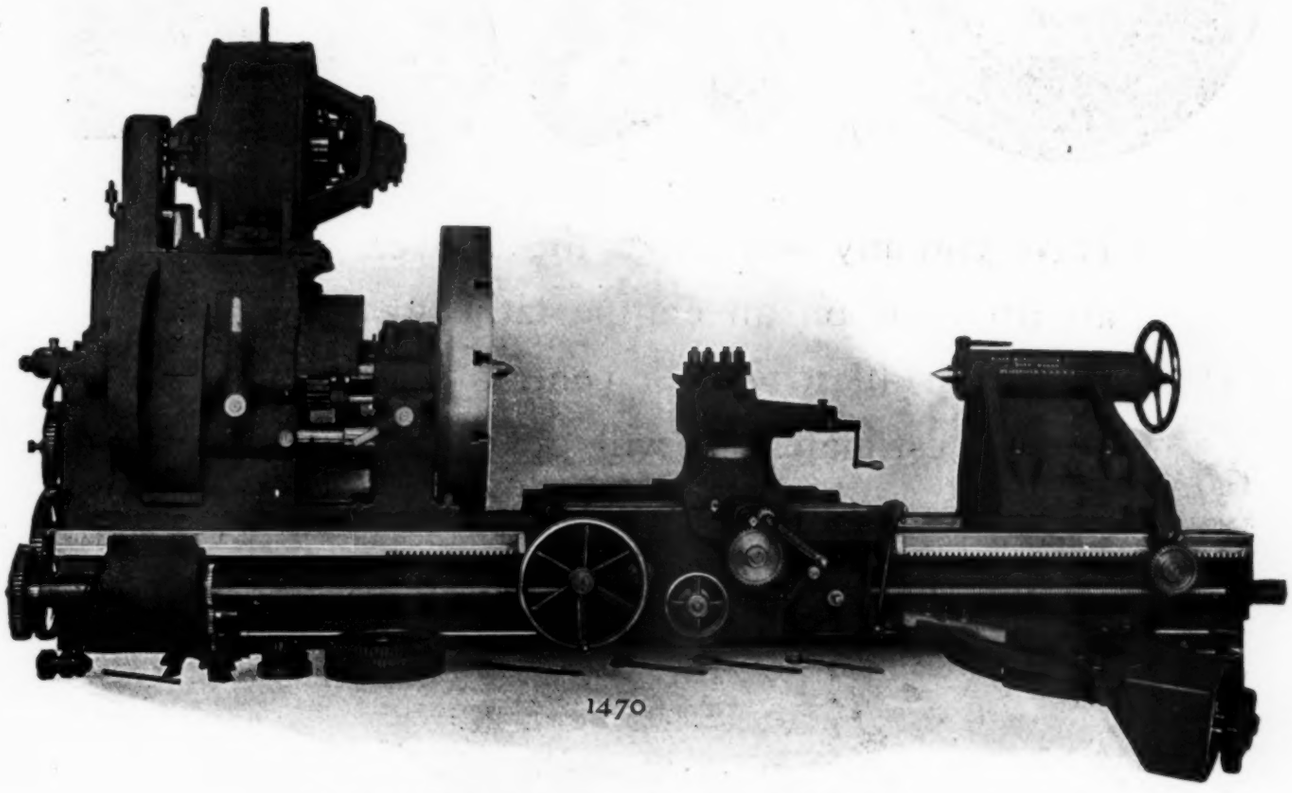

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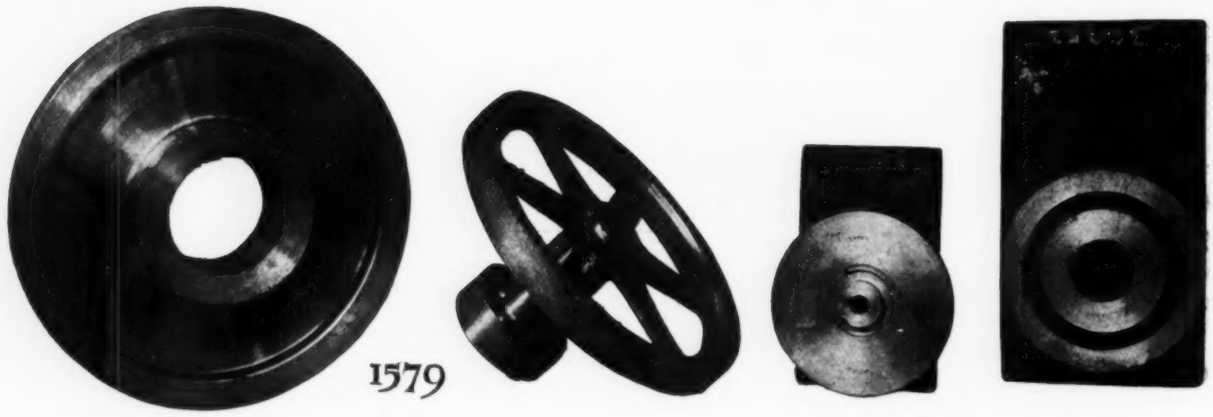

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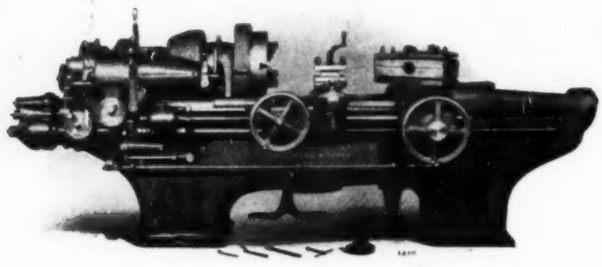

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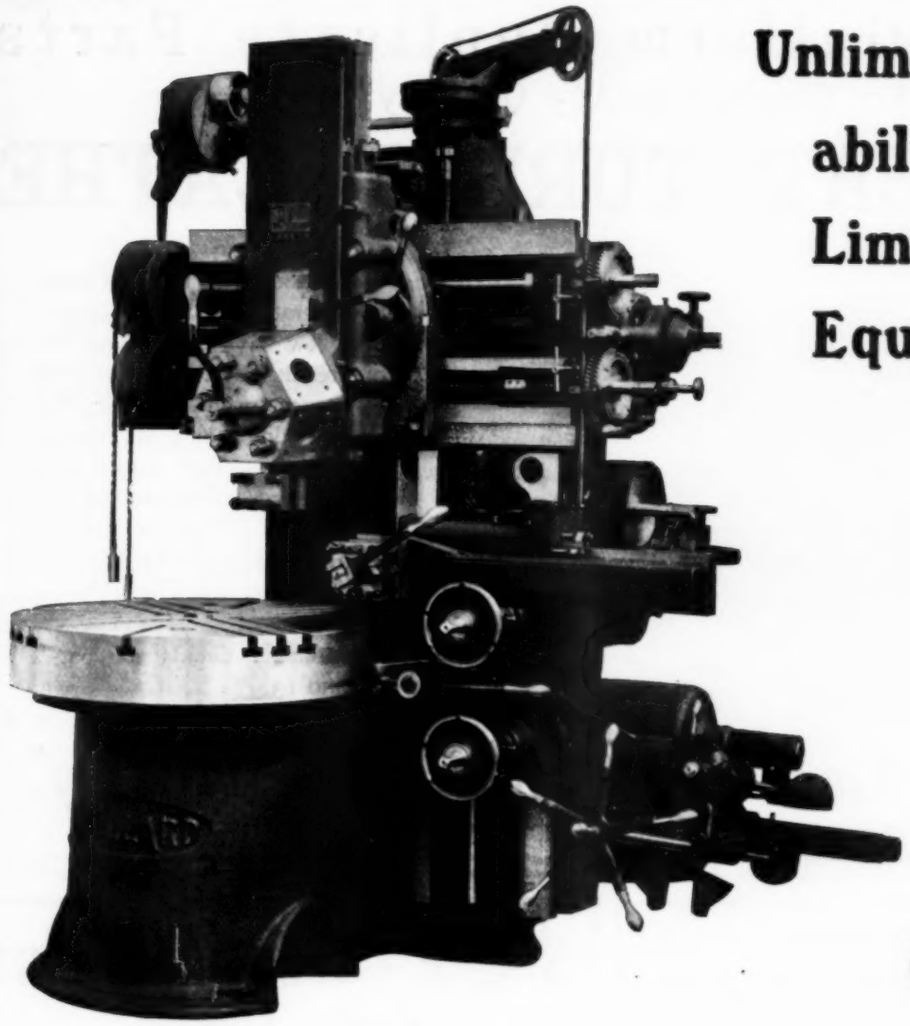

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THE FLAT TURRET LATHE

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For further details see pages 12 and 13.

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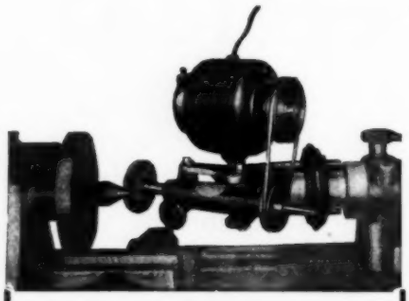

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DIAMOND MACHINE CO.,

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Forming Tools for Automatic Screw Machines*

Making Circular and Dovetail Forming Tools with Proper Clearances and Dimensions and Applying Them to Screw-machine Work

BY C. L. GOODRICH† AND F. A. STANLEY‡

Quite a variety of types of cutting tools and holders have been developed for cross forming work on the automatic screw machine.

For brass work flat-formed blades such as shown by Fig. 1 or solid forged tools as in Fig. 2 are found very satisfactory, owing to its being possible to obtain with these perfect side and peripheral clearances.

Where frequent sharpening of the tool is required and where the form produced must be kept uniform, these tools are not always satisfactory and a tool whose cutting edge can be sharpened without any alteration to its contour is generally preferred. Fig. 3 illustrates what is usually known as a circular forming tool. The grinding is done on face *a b c d*, the form as indicated extending entirely around the periphery. Fig. 4 illustrates another type of forming tool which admits of the cutting edge being reground without alteration of its contour. This is known by various names, a very common one being dovetail forming tool from the fact of its generally having a dovetail to fit into its holder. To prevent any confusion this tool will be referred to as a dovetail forming tool hereafter in this article. These tools are generally held and fed in such a manner that the cutting edge is on a radial line with the work being formed. In some special cases, however, it is found more satisfactory for the tool to travel tangentially to the work instead of radially.

Comparison of Types

There are various things to be taken into consideration when determining whether to use a circular or a dovetail forming tool and the following points may be of assistance when making the decision:

1. The peripheral clearance angle being constant in both circular and dovetail tools, as shown by Fig. 5, it is clear that in the dovetail type there is more metal directly under the cutting edge than in the circular tools to conduct away the heat which is produced while forming.

2. The difficulty and cost of producing an accurate and smooth form leave much in favor of the circular forming tool.

3. The type of tool post required for a circular forming tool oftentimes interferes with turret tools simultaneously operating on work with the cross-slide tools. The dovetail type of tool permits of the use of holders which do not thus interfere.

4. The increasing peripheral clearance of a circular forming tool permits a lesser angle to be utilized at the point of cutting than with the dovetail type, and this lesser angle has a tendency to prevent chattering on account of the support afforded. With the dovetail type, stoning the clearance face is sometimes resorted to, which in effect gives a lesser angle at the cutting point, as indicated in Fig. 6 at *B*.

A similar result with the circular tool *without* stoning the clearance edge is obtained by properly determining the relation of the center of the cutter to the center of the work as shown at *B'*, Fig. 7. Raising or lowering the cutting edge of the tool changes the clearance angle and incidentally changes the form produced. Consequently the clearance angles and the relation of the center of the cutter holding bolt to the work center are points which it is necessary to consider carefully.

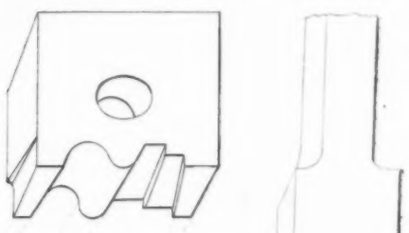
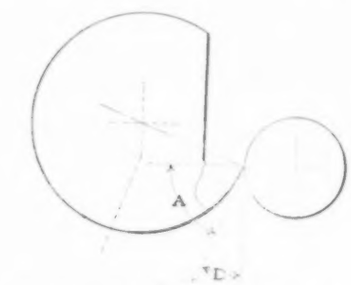


FIG. 1

FIG. 2



Dotted Line is Clearance Angle of Circular Tool and Corresponding Edge of Dovetail Tool.
Cross Hatched Space indicates Metal in Circular Tool to Conduct away Heat.
A indicates Metal in Dovetail Tool to Conduct away Heat.
D Amount of Clearance at Cutting Edge.

FIG. 5

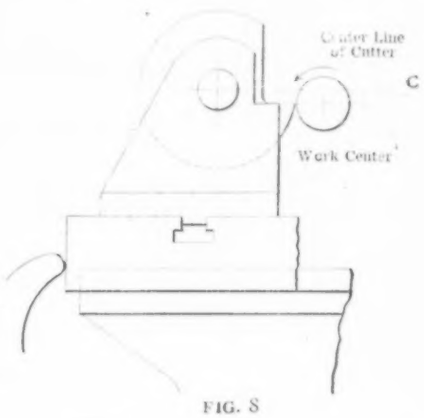


FIG. 8

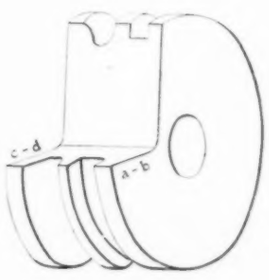


FIG. 3

FIG. 4

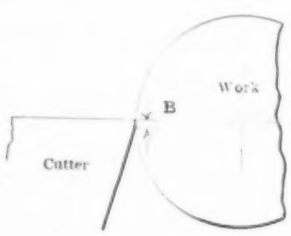


FIG. 6

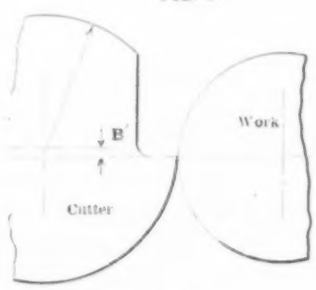


FIG. 7

FORMING TOOLS AND THEIR CLEARANCES

*Copyrighted, 1908, by Hill Publishing Company.

†Department foreman, Pratt & Whitney Company.
‡Associate editor, AMERICAN MACHINIST.

Diameters and Clearances

With a given material the larger the diameter of the work the greater the angle of clearance required. Clearance angles are seldom less than 7 degrees and seldom over 12 degrees except on work out of the ordinary run.

The diameter of circular forming tools is an important point to consider. A small diameter has a more pronounced change of clearance angle than a large diameter. In fact, when of an exceedingly large diameter the circular tool approaches in cutting action the dovetail type of tool.

On the Pratt & Whitney automatic screw machines the standard outer diameters of circular forming cutters are as follows:

No. 0 machine, 1¾-inch O. D. cutter.
No. 1 machine, 2-inch O. D. cutter.
No. 2 machine, 2⅛-inch O. D. cutter.
No. 3 machine, 3-inch O. D. cutter.

In order to obtain suitable peripheral clearance the practice is to locate the center of the cutter above the center of the work as at *C*, Fig. 8; the tool holder being bored out above the center as indicated and the forming tool milled out below center a corresponding amount so that its flat cutting surface is level with the center of the work. A very satisfactory amount to locate the circular tools above center and cut their working edges below for the machines just referred to is as follows: For No. 0 machine, ⅛ inch; No. 1, 3/16 inch; No. 2, 3/16 inch; No. 3, 3/16 inch.

Getting the Tool Diameters at Different Points

In order to produce a circular or a dovetail type of tool so that the contour of its cutting edge is such as to produce correct work the amount a circular tool is off center as *C* in Fig. 8 and the clearance angle of a dovetail tool as at *D*, Fig. 5, must be known. In connection with the circular type of tool the diagrams Figs. 9, 10, 11 and 12 will be found convenient for quickly ascertaining the diameters of the various sections of the tool. The method of using these diagrams is given in Fig. 10.

NO. 0 AUTOMATIC FORMING TOOLS 1¾″ OUTSIDE DIA. CUTTING EDGE ¼″ BELOW CENTER.

AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER.

EACH GRADUATION = .0001 ($\frac{1}{10,000}$) INCH.

EACH GRADUATION = .005 ($\frac{5}{1000}$) INCH.

DIFFERENCE IN DIAMETER OF SAMPLE.

FIG. 9

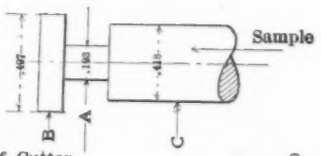
NO. 1 AUTOMATIC FORMING TOOLS 2″ OUTSIDE DIA. CUTTING EDGE $\frac{3}{16}$″ BELOW CENTER.

AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER.

EACH GRADUATION = .0001 ($\frac{1}{10,000}$) INCH

EACH GRADUATION = .005 ($\frac{5}{1000}$) INCH.

DIFFERENCE IN DIAMETER OF SAMPLE.



Example: to find the Actual Diameter of Circular Forming Tool at B for #1 Auto. Screw Machine.

Diameter at A = Standard Outside Diameter of Forming Tool = 2.00″

Difference in Diameter of Sample = .497 − .193 = .304. Apparent Diameter of Cutter, or Diameter if Cutting Edge were on Radial Line = 2.00 − .304 = 1.696.

Opposite .304 (Difference in Diameter of Sample) on Lower Scale Read on Upper Scale the Amount to be Added to Apparent Diameter = .0064.

Therefore Actual Diameter of Circular Forming Tool at B = Apparent Diam. (1.696) + .0064 = 1.7024.

Example; —
To Find Actual Diam. of Forming Tool at C

.418 Diam. Sample at C
.193 " " " A
.225 Dif. in Diam. of Sample

2.000 Diam. Tool at A
.225 Dif. in Diam. of Sample
1.775 Apparent Diam. of Tool
.0046 Amt. to Add (from Scale)
1.7796 Actual Diam. of Tool at C

FIG. 10. DIAGRAMS FOR FINDING ACTUAL DIAMETERS OF CIRCULAR FORMING TOOLS FOR P. & W. NOS. 0 AND 1 AUTOMATICS

Where different diameters than those given in the diagrams are used, or when the amount the cutter center is set off from the work center varies from the diagrams, the following formula may be used in connection with Figs. 13 and 14.

$$f = g - \sqrt{g^2 + a^2 - \left(2a\sqrt{g^2 - c^2}\right)}$$

To compute the measurement *T* on

dovetail tools, Figs. 13 and 15, the formula would be:

$$T = a \text{ (cosine } A)$$

Ten degrees is a very common clearance for dovetail tools; cosine $10° = 0.98481$.

Tool-making Methods

There are various methods employed by the toolmaker in accurately making circular and dovetail forming tools. The form of tool has considerable to do with the scheme selected. For instance if the work is entirely without curved or irregular outline the tool, if circular, would be simply turned up in an engine lathe to the correct dimensions, sometimes making allowance for grinding, and then milling out a section for the cutting edge. In case the cutter in question is of the dovetail form and has been correctly dimensioned no difficulty will be experienced in accurately planing to dimensions if the toolmaker has proper dimensioned size blocks. The depth micrometer also is of value in this work. Sometimes fly cutters are also used for making these dovetail tools.

The Transfer Scheme

It sometimes happens that circular cutters are to be made which are very difficult to caliper; it is then quite frequently advisable to turn a tool setting gage of the correct diameter and copper plate the gage (using blue vitriol) and then to size the cutter correctly by first bringing a master tool into contact with the gage, noting the graduation on the

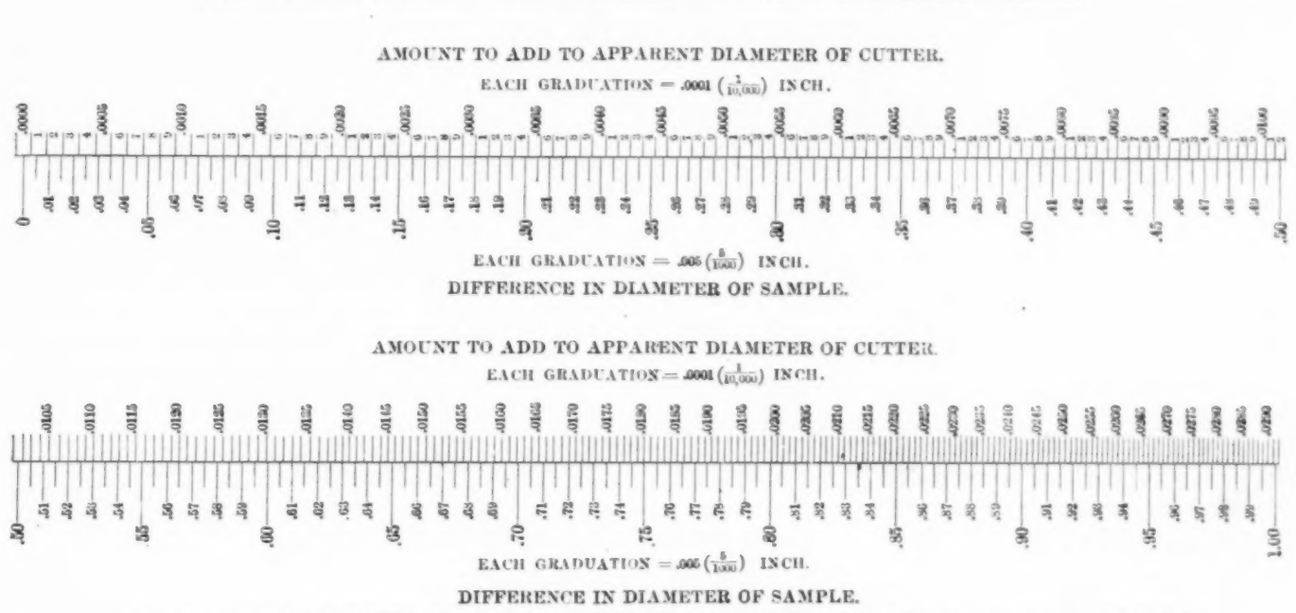

NO. 2 AUTOMATIC FORMING TOOLS 2¼" OUTSIDE DIA. CUTTING EDGE 3/16" BELOW CENTER.
AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER.
EACH GRADUATION = .0001 (1/10,000) INCH.
EACH GRADUATION = .005 (5/1000) INCH.
DIFFERENCE IN DIAMETER OF SAMPLE.
AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER.
EACH GRADUATION = .0001 (1/10,000) INCH.
EACH GRADUATION = .005 (5/1000) INCH.
DIFFERENCE IN DIAMETER OF SAMPLE.

FIG. 11. DIAGRAM FOR FINDING ACTUAL DIAMETERS OF CIRCULAR FORMING TOOLS FOR P. & W. NO. 2 AUTOMATIC

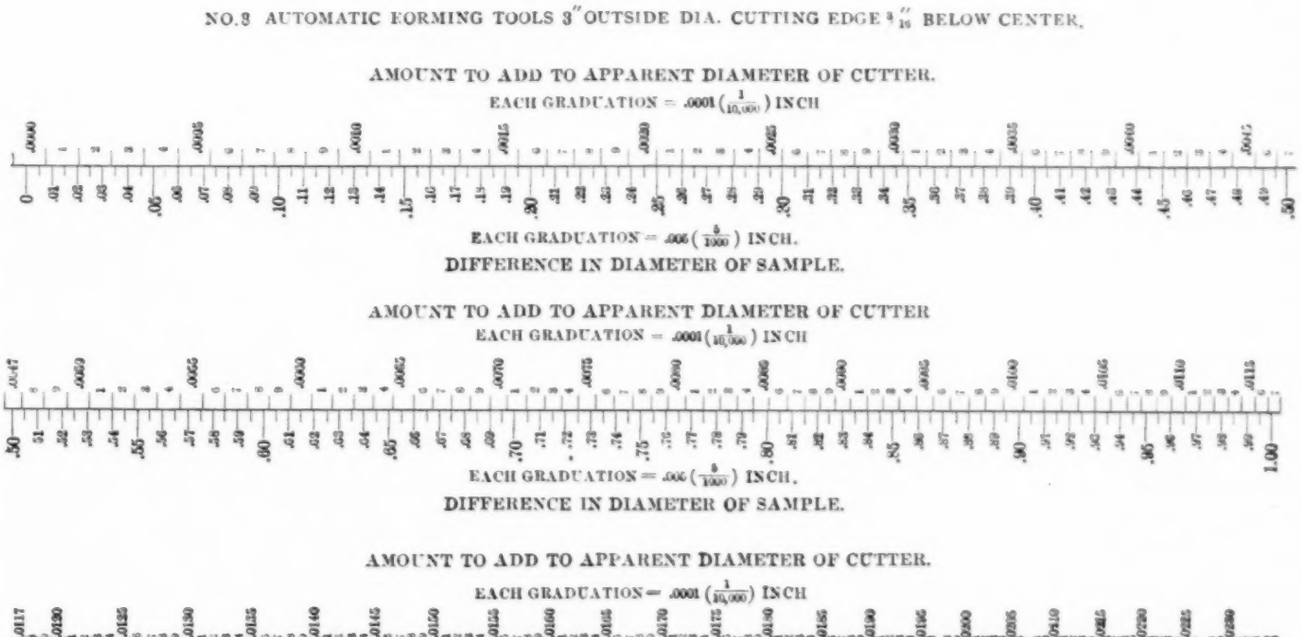

NO. 3 AUTOMATIC FORMING TOOLS 3" OUTSIDE DIA. CUTTING EDGE 3/16" BELOW CENTER.
AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER.
EACH GRADUATION = .0001 (1/10,000) INCH
EACH GRADUATION = .005 (5/1000) INCH.
DIFFERENCE IN DIAMETER OF SAMPLE.
AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER
EACH GRADUATION = .0001 (1/10,000) INCH
EACH GRADUATION = .005 (5/1000) INCH.
DIFFERENCE IN DIAMETER OF SAMPLE.
AMOUNT TO ADD TO APPARENT DIAMETER OF CUTTER.
EACH GRADUATION = .0001 (1/10,000) INCH
EACH GRADUATION = .005 (5/1000) INCH.
DIFFERENCE IN DIAMETER OF SAMPLE.

FIG. 12. DIAGRAM FOR FINDING ACTUAL DIAMETERS OF CIRCULAR FORMING TOOLS P. & W. NO. 3 AUTOMATIC

micrometer collar on the feed screw of the lathe, then moving the carriage longitudinally and bringing the master tool down upon the cutter to the same position. This scheme admits of several master tools being used and in connection with micrometer stops or suitable size blocks for the longitudinal movement of the carriage accurate circular tools can be economically made.

Fig. 16 illustrates this transfer scheme, corresponding numbers indicating corresponding diameters of model and cutter. By simultaneously using a fixed dead tool arranged as a stop on center against the gage before referred to and a master tool off center the amount the circular cutter is off from the work-center, the gage may be made of such diameters as would be correct with the cutting edges of the circular cutter on the radial line instead of being off center. Another modification of the scheme is to dispense with the dead tool or stop referred to and use a rigid master-tool-holding block capable of rapid vertical adjustment which will permit of setting the master tools to the gage while on center and then allow them to be dropped below center an amount equal to the amount the cutting edge of the cutter is off center. This permits very accurate cutters to be produced. Fig. 17 will give an idea of this method.

Sometimes it is found convenient first to rough out the circular forming tool and next mill out the space for the cutting edge and thus permit the master tool to be used without the chance of error creeping in which might occur on account of the necessity of moving the cross slide of the carriage in and out.

It will be found of advantage to use tissue paper feelers between the master gages and the tools in these transfer methods. Some toolmakers prefer merely copper plating the master and just burnishing the copper surface to show contact previous to transferring.

Master Tools and Templets

When irregular shaped circular forming tools are produced by direct micrometer measurements, the master tool is generally made of the same contour as the work that is to be produced; consequently the master tool when finishing the circular tool must be held off center an amount equal to the amount the cutting edge of the circular tool is off center. The sequence of operation in making a circular tool from a given model or drawing is shown in Fig. 18. First is prepared a master tool templet *A*, and then a master tool *B*. The templet is of sheet steel and should be made from a rectangular piece that is perfectly square to facilitate measuring with a micrometer. Considerable skill is required to file complicated forms accurately. The master tool *B* is shaped exactly to fit the master tool templet *A* and is also made perfectly square to permit measuring with a micrometer.

The circular tool is formed by the latter as previously outlined and as shown in Fig. 18. Owing to the thin scraping chips taken when finishing a cutter to exact size the master tool may have a tendency to glaze instead of cutting. The use of turpentine prevents the glazing by assisting the tool to take hold on very thin chips. In some cases two or more master tools are found more convenient than the one, especially in making wide circular forming tools, and in this event it is customary to make a male sheet-steel gage *C*, Fig. 19, for convenience in testing the longitudinal positions of the various cuts in the circular tool. This latter gage does not require the complete form as it is commonly used for longitudinal work only.

Making Dovetail Tools

In planing dovetail tools size blocks may be used as already mentioned for setting

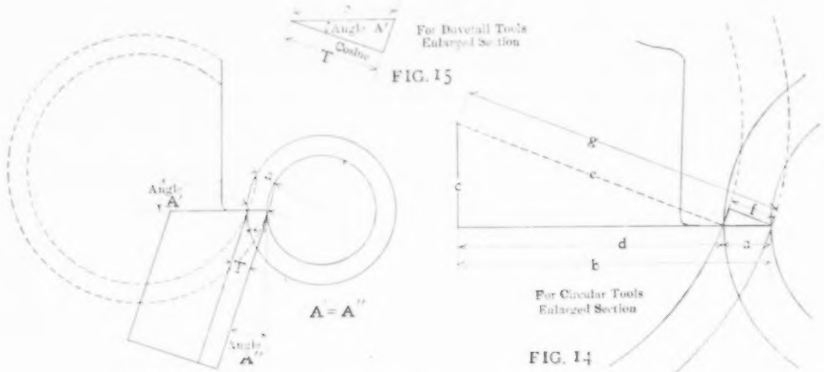


FIG. 15

FIG. 13

FIG. 14

FINDING CUTTING DEPTHS OF FORMING TOOLS

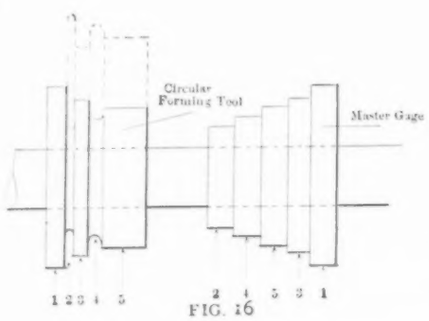


FIG. 16

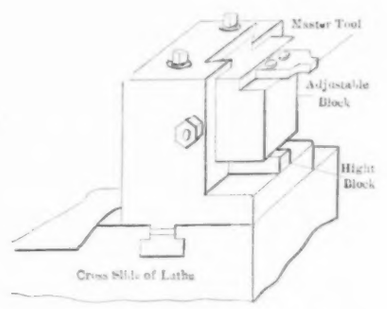


FIG. 17

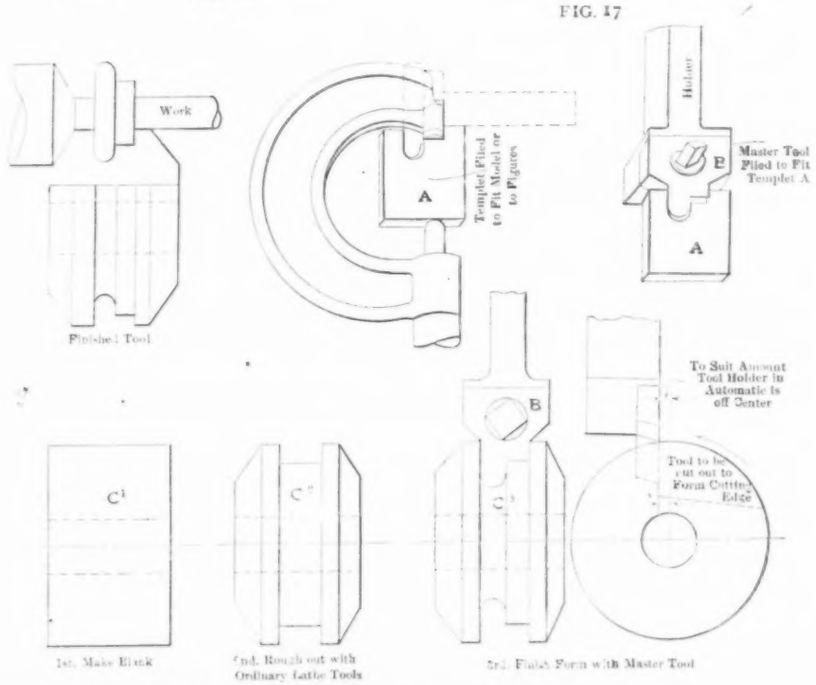

Work
Finished Tool
A
Templet Filed to Fit Model or to Figures
Holder
B
Master Tool Filed to Fit Templet A
To Suit Amount Tool Holder is Automatic is off Center
Tool to be cut out to Form Cutting Edge
1st. Make Blank
2nd. Rough out with Ordinary Lathe Tools
3rd. Finish Form with Master Tool

FIG. 18. MAKING CIRCULAR FORMING TOOLS

the planer or shaper tool to the various hights required. A stop screw may be located as at *a*, Fig. 20, and size blocks used as at *b* for regulating the setting of the head. Or a depth micrometer may be used instead of the stop screw, tissue-paper feelers being used in either case. Size blocks may also be used directly on the plate in many cases, the tool being brought down into contact with the different blocks for getting the depths of the various grooves, etc., in the cutter blank.

In using a formed tool of same contour as the model in planing the dovetail tool as in the enlarged sketch in Fig. 20, the formed tool is held in the post at the same angle as the dovetail tool will afterward be used on the work. The dotted lines indicate the angle to which the working edge will be finished and the planing tool is shown set at the same angle.

In planing the dovetail form of tools it will sometimes be found of advantage to plane the face of the cutting edge of the blank to the correct angular relation to the clearance face as at *A*, Fig. 21, and then scribe the contour desired on this cutting face from a templet.

If the templet is fastened to a block as shown, the shape of the finished soft cutter may also be nicely tested as in Fig. 22.

As frequent hardening and annealing of tool steel is liable to reduce its quality, various expedients are resorted to in order to test the correctness of tools without undue waste.

Testing Outline of Forming Tools

A common scheme is to mill the circular tool as in Fig. 23, where *a* is the actual cutting edge and *b* a trial cutting edge. The cutter is hardened at *b* only and a piece of work is formed by this edge. If incorrect, the cutter edge is annealed at that point and then corrected. Another method is to insert a flat piece of steel as in Fig. 24, and after forming, the test piece is removed and hardened to test the accuracy of the form in the cutter.

A glass plate is frequently found convenient when testing the outline of a circular tool with a templet, the sketch, Fig. 25, showing the application clearly.

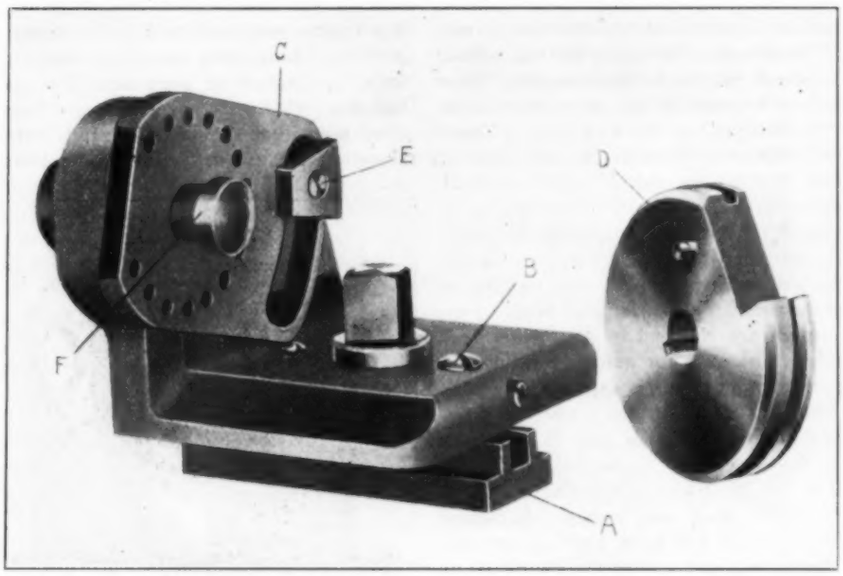


FIG. 27. ADJUSTABLE TOOL POST FOR CIRCULAR FORMING TOOLS

Narrow circular cutting-off tools and in fact almost all delicate circular forming tools which are apt to be cracked by hardening are benefited by having radial slots milled in as shown by Fig. 26, they are then less liable to crack than when left solid.

Tool Posts

There are many types of tool posts for holding cross-forming and cutting-off tools. Fig. 27 is a very satisfactory post made by the Pratt & Whitney Company for holding circular forming tools. This

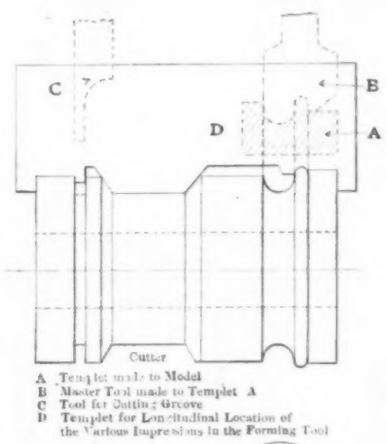


FIG. 19

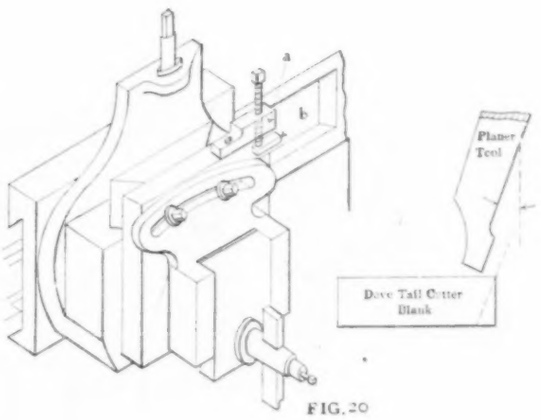


FIG. 20

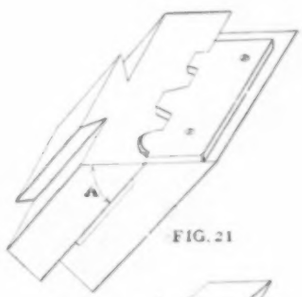


FIG. 21

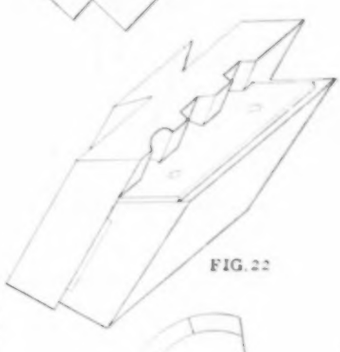


FIG. 22

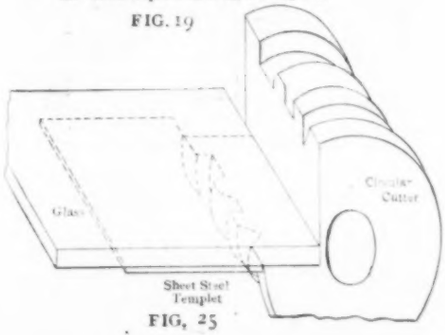


FIG. 25

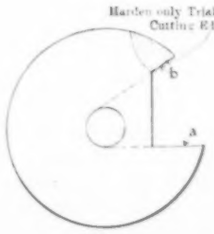


FIG. 23

FIG. 24

FIG. 26

MAKING CIRCULAR AND DOVETAIL FORMING TOOLS

has an adjustable swivel tongue or guide *a* which is controlled by an eccentric pin *b*. The cutter is doweled to the tool holder *c* by pin *d* and the holder after the cutter has been brought in to correct position is firmly clamped to the tool post. There are a number of holes in the tool holder *c* which permit the cutter to be doweled until entirely worn out. The holder is clamped by screw *e*, and being considerably further from the center of cutter than the cutting edge insures rigidity in this respect. The cutter and holder furthermore are clamped by the center tool binder *f*. A gage for quickly locating the cutter edge on center is part of this equipment. Fig. 28 illustrates a pair of these posts in position and a gage is shown at *g* in the drawing.

Fig. 29 illustrates a circular forming-tool holder with two varying diameters of tools which has been used on automatics equipped with magazines for cast-iron sewing-machine hand wheels and similar work where considerable variation in diameters would require a very large circular tool of the ordinary type, which would be unsatisfactory as regards peripheral clearances.

Fig. 30 is a common dovetail tool holder and post. Fig. 31 represents another style of tool post for holding the dovetail type of tool. Fig. 32 shows a tool post for holding flat tools. The tool is clamped by screws *a* in swinging block *b* which is adjusted by screws *c* and clamped fast with the tool post to the cross slide by nut *d*. An eccentric pin *e*, adjusts the tool to position vertically and the swinging block gives the required adjustment for side clearance.

There are numerous other types, where provision is made for adjusting the tool vertically by wedges, swinging anvils, etc. Fig. 33 illustrates one of these posts with swinging anvil.

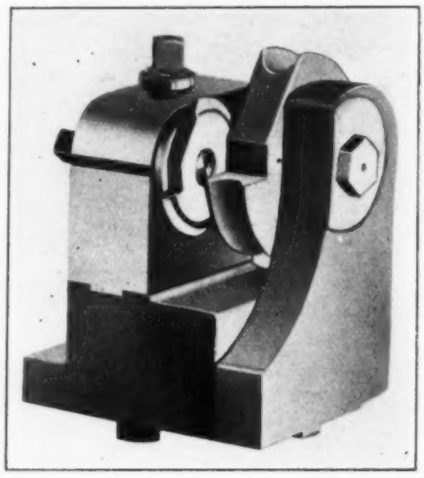


FIG. 29. TOOL POST FOR TWO CIRCULAR TOOLS

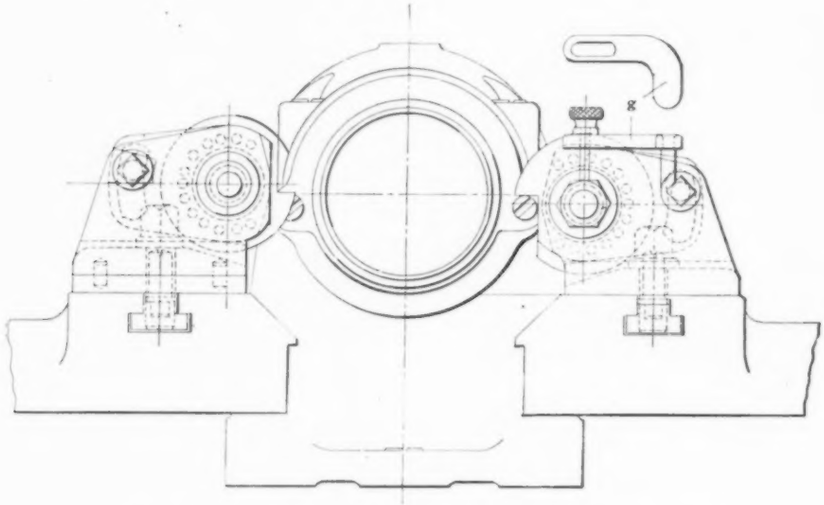


FIG. 28. ADJUSTABLE TOOL POSTS FOR CIRCULAR FORMING TOOLS

Application of Tools to Work

Generally, circular dovetail forming tools do not have perfect side clearance. This feature was discussed in the article on "Why Chips Cling to Screw Machine Tools," published at page 112, Vol. 30, Part 2.

One point that should be carefully considered in the use of cross-forming tools is whether it is most desirable to use a tool with the forward or reverse movement of the spindle. This is of particular importance when the forward and reverse speeds are greatly at variance, which is generally the case, as the production per hour may be greatly increased or decreased according to these conditions. The question as to whether a cross-feeding tool is to be in cutting action simultaneously with an opposite cross-feeding tool, or with a tool in the turret is also to be considered in the connection.

Fig. 34 illustrates a variety of work which is common to the automatic screw machine and shows various arrangements of forming tools, several of which are adapted for simultaneous operations of front and rear tools which many times is conducive to a high rate of production as the cuts taken with each tool may be greater than if either were operating alone as the side pressure on the work is balanced. When the construction of the machine does not permit of the simultaneous cutting action, a similar arrangement of tools is satisfactory; only the time and sequence of their operations must be taken into consideration.

Forming and Turning

There are a number of important details regarding the shape and method of using forming tools some of which will now be touched upon: Sketches *A*, A^1, A^2. Fig. 34, indicate a method of forming and cutting off a piece with two tools, one of which is, of course, fed into the work before the other. The burs indicated by arrow points at A^2 are due to the rubbing of the forming tools on the side cuts and unless there is perfect side clearance to the forming tool, the bur will be increased. By adding a bevel edge to the tool, as shown by *A*, the bur produced is removed. A^1 is a refinement over *A*. At *B* is illustrated a common method of simultaneously cutting off and forming shoulder screws, the two tools finishing their cuts at the same time. Where a machine with single cross slide is used for producing work in this fashion, the cutting off tool should precede the forming tool as the bar then has its full diameter and strength for the cutting off operation. Sketches *C* to C^5 show an ordinary screw in which the head is to be formed by cross-slide tools and the body turned by a box tool or hollow mill in the turret. The cross-slide tools start their cuts together, but the forming tool for the head, of course, has to finish first. The cutting off tool should be made so as to bevel the end of the bar as shown, in order to permit the starting of the box

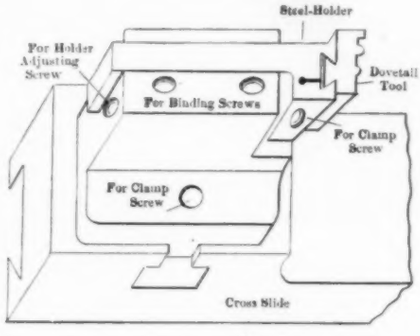


FIG. 30. POST FOR DOVETAIL TOOL HOLDER

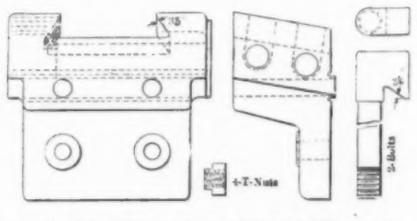


FIG. 31. DOVETAIL FORMING TOOL POST

tool on a light cut until its back rest has a good support.

The forming cutter for the head should be beveled as at c in C^1 in case the box tool follows the forming cut. This allows the tool to cut into the stock as at C^2, leaving a beveled shoulder so that when

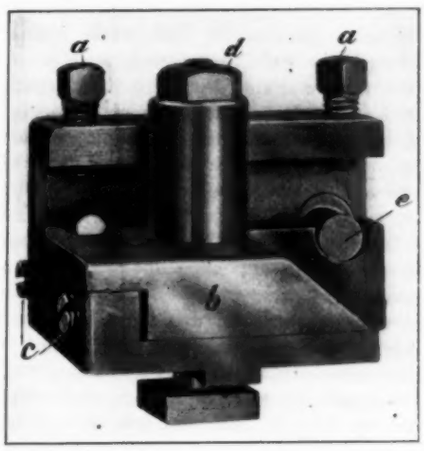


FIG. 32. POST FOR STRAIGHT CUT-OFF AND FORMING TOOLS

the box tool is fed along it completely removes the superfluous metal without leaving an objectionable ring which is quite apt to be produced under the conditions represented in C^4 and C^5. The ring of metal there seen which is a result of the square shoulder cut by the forming tool in C^4, is quite apt to tip over on the screw blank and cramp and to later on prevent the die from cutting the thread properly.

Supporting Long Work

At D is illustrated a method of forming and cutting off long pieces where it is generally advisable to use a supporting device as indicated. It is obvious that the two cross-slide tools are not used simultaneously in this case. The bevel at D left by the first tool prevents the work breaking off prematurely. E is a very simple piece to produce. Where there are double slides on the machine the two tools may start their cuts at the same time, but the rear tool, of course, merely chamfers the edges of the work. This bevel cutter is a refinement not always required, but it is desirable when the bur which would be produced by the front tool is objectionable.

Making Short Screws and Other Parts

At F, F^1, F^2 and F^3 are shown several methods of forming and cutting off short screws. The method at F is a rapid one and is particularly recommended for machines with one cross slide, the cutting off of the finished screw being accomplished at the same time the forming of a new blank is being done and requiring a traverse movement of only about one-half

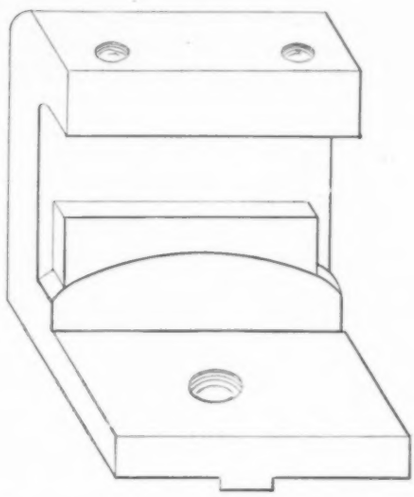


FIG. 33. TOOL POST WITH ADJUSTABLE SHOE

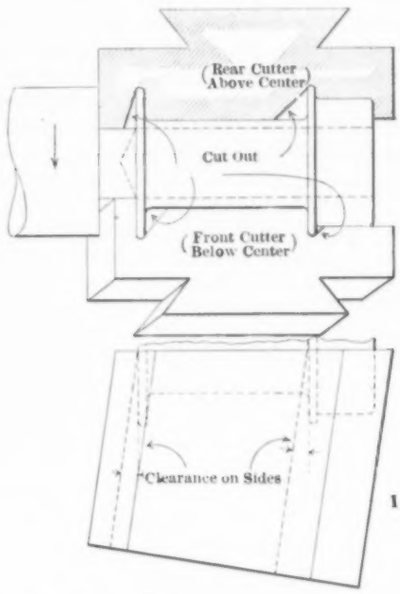


FIG. 35. FORMING WITH A PAIR OF DOVETAIL TOOLS

the radius of the work. F^1 and F^2 are applicable only to a machine with double cross slides in case simultaneous cutting action is desired. These two methods are rapid, both tools finishing their cuts at the same time. F^3 requires a more costly tool outfit, but on account of balancing

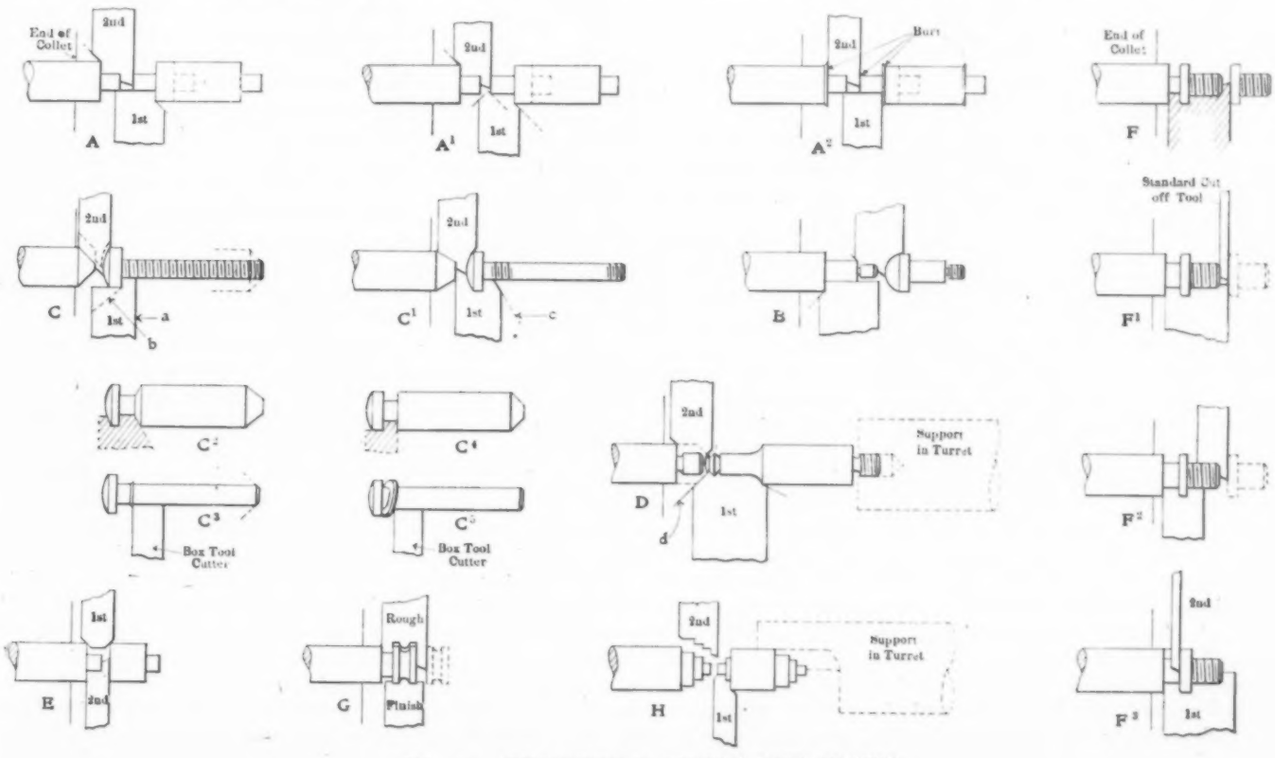


FIG. 34. APPLICATIONS OF FORMING TOOLS TO WORK

the cut is preferred where coarse feeds are taken or long work is to be formed. The method of producing short screws indicated in F^3 makes use of a rear cutting off tool after the forming tool has completed its work.

G illustrates a scheme which is of value where roughing and finishing cuts are required on exceedingly accurate work. The roughing tool cuts off the piece previously formed and leaves a light cut for the finishing tool to take on the work outlined. *H* is self explanatory, indicating the value of the turret support for the work.

A Pair of Dovetail Tools

A method is shown in Fig. 35 for getting perfect side clearance in dovetail forming tools. The front tool is used for finishing the left-hand sides of the work flanges and the rear tool for finishing the right-hand sides and the end, the tools being inclined in opposite direction so as to obtain clearance for these cuts. The tools are cut out as indicated by the arrows, at diagonally opposite points so that each cutter will clear the surfaces finished by the cutter opposite. Similarly, side clearance to circular tools is possible by inclining their axes.

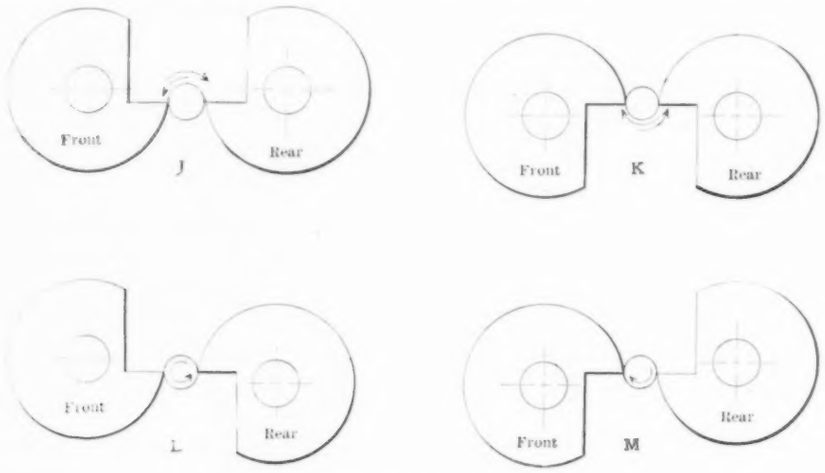


FIG. 36. FORMING TOOL POSITIONS

Arrangement of Circular Tools

In Fig. 36, sketches *J*, *K*, *L*, *M* show various ways of arranging forming tools with reference to the direction of rotation of the spindle. These are to be considered as being viewed from the turret, looking toward the head spindle. The arrangement at *J* is a most common one when a spring screw die or a tap is to be used. The low-speed forward drive of the spindle is used for the cross forming of the work (as at C-C^1, F-F^3, Fig. 34), while the high reverse speed is utilized for removing the die or tap and for light cutting off cuts like that at F^3. At *K* is a similar arrangement to *J*, and in some cases this is substituted for the former, particularly where the die or tap has a left-hand thread; the cutting off tool is used at the front and the heavier forming cuts taken from the rear in this event.

L and *M* show arrangement of tools where they operate simultaneously or where there is no necessity for reversing the direction of rotation of the head spindle. In this latter case the spindle speeds generally differ, and by carefully selecting the proper speeds a high rate of production will be possible. In all cross forming work it is essential that the spindle fit snugly in its front bearing and that the collet or chuck has a good parallel contact with the bar which is being formed. A bell-mouthed collet is most frequently the cause of chattering, although excessive clearance may also promote chattering.

The tool holder should be of such design as to hold the tool firmly and the cross slide of such dimensions and so gibbed as to permit of no spring or shake. With careful attention to these details and providing the cuts are supported from the turret when they are wide and also providing the design of the tool and the question of clearances are carefully considered, excellent results should be obtained.

The rates of feed and the subject of lubricants have been discussed in articles previously published. Obviously speeds, feeds, and lubrication all have an important bearing on results attained in the automatic.

From the earliest times in the history of watchmaking it has been the custom of watchmakers to reduce fresh bread to the form of dough. This is done by steaming and kneading. They then use this dough for removing oil and chips that naturally adhere, in the course of manufacture, to pieces as small as a part of a watch. There are many parts of a watch, by the way, that are so small as to be barely visible to the naked eye. The oil is absorbed by this dough, and the chips stick to it, and there is no other known substance which can be used as a wiper without leaving some of its particles attached to the thing wiped.

Thread-miller Work

By E. Theodore

When I first started to work as a toolmaker, most up-to-date shops had one universal grinder for tool work, and I doubt very much if anyone thought at that time that the grinder would go out into the shop and take its place alongside of the lathe as a manufacturing proposition. The thread-milling machine seems to be evoluting in a direction quite the reverse of the grinder.

In my travels I have noticed thread millers in many machine-tool plants where they seem to be considered necessary in the manufacture of lead screws, worms and the like, in quantities, but I had never considered it as a jobbing machine until I was given a practical demonstration by the superintendent of a shop which is thoroughly up-to-date and makes a point of keeping abreast of the times.

He had one of the Pratt & Whitney thread millers and he asked me to see it put through its paces. The piece in question was very well suited to bring out the points of the machine. It was a milling-machine arbor made of unannealed tool steel, to be threaded for the nut; the end had been hardened and this black end and the shiny side surely looked like trouble.

The toolmaker took a cutter from a board which seemed rather generously supplied, slipped it on the spindle and ran on the nut. Then from a table supplied with the machine he got the angle for the pitch, loosened the head, and swung it to the proper degree by the graduations, tightened it up, then referred to the chart again for the gears. In this case only one had to be changed. He then put a dog on the work, put it between the centers, started the machine and ran the cutter in until the point just touched the work, then set the dial on the feed screw to zero, ran the cutter clear off the work, fed in to depth by thousandths by reading the dial, threw in the feed and turned on the oil.

Up to this point it seemed to me that the race with the lathe was very close, but from here all comparisons ceased. It was surprising the way that cutter got around the work, and in about the time it would take to get the point off of a lathe tool the first time, the job was finished.

The man then took it from the centers, turned on the nut and handed it to me for inspection. It was all that could be desired for fit, and as clean and smooth as a gage. He explained that if the cutter was sharp and the work turned exactly to size he could make at will the first time, a tight, good, or loose fit by means of the micrometer readings when feeding in the cutter.

Two Speeds from a Constant-speed Drive

By Albert Walton

In textile mills there is a class of machines which it is necessary to start very slowly, and which must occasionally be run at a very slow speed for considerable intervals of time, although the normal operating speed is much higher. Warpers, beamers, slashers, ballers, etc., fall in this class. They are machines which, in general, are used for winding the finished yarn on huge spools preparatory to the weaving processes. The yarn is reeled off from an immense number of small spools, or from a few very large ones, and it is necessary to start slowly in order to overcome the inertia of the spools without breaking the fine threads. If the machines were started, for instance, by throwing a belt from a loose pulley onto a tight one, every thread would snap before the spool from which it was being taken could start to revolve. As there are often as many as 5000 threads handled at once, this would be nothing short of a catastrophe.

To overcome this difficulty when driving with a belt from a constant-speed shaft, an ingenious device is used. This is shown in Fig. 1. Between the loose pulley and the driving pulley is inserted a narrow slow-speed pulley only about one-half the width of the others. On the hub of this slow-speed pulley is mounted a small spur gear which meshes with one of two intermediate gears, the other of which drives an internal gear on the inside of the rim of the driving pulley. The driving pulley is loose on the shaft and is attached to a pinion which drives the machine gear. Both driving pulley and pinion are free to revolve on the shaft; however, the arm which carries the two intermediates is fast to the shaft, held by a set-screw as shown. The shaft can revolve in a forward direction, but is kept from turning backward by a ratchet and pawl mounted on its inner end. When the belt is shifted from the loose pulley it first runs onto the narrow slow-speed one. This revolves about the shaft, and the gear on its hub drives the driving pulley slowly through the train of two intermediates which are carried on the arm attached to the shaft. The shaft cannot turn backward on account of the pawl.

When the belt is shifted onto the driving pulley, the two intermediates and the arm carrying them are carried around in a forward direction, since the ratchet and pawl only allow the shaft to rotate in that direction. If it were not for this arrangement the driving pulley would now be driving back through the intermediates to the slow section, which would then have to revolve at a high rate of speed. Thus it is possible to drive the driving pulley from the slow-speed pulley, but not to drive back in the other direction.

As part of the extensive application of individual motors to cotton machinery, it fell to my lot to develop a similar drive with a constant-speed motor and a gear in place of the pulleys and belt. Fig. 2 shows how this was accomplished. It was necessary to arrange the new drive so that it would be put in operation by

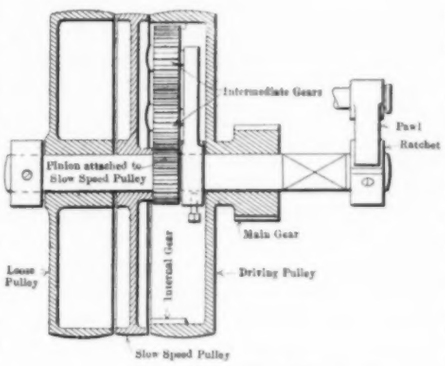


FIG. 1. A TWO-SPEED BELT DRIVE

exactly the same motions on the part of the person operating the machine as were required with the belt drive. It will be seen that the loose pulley and the slow-speed pulley were removed and replaced with a flange bolted to the side of the driving pulley and a gear with a "friction face" at its side. The flange was faced with leather. The gear was arranged so that it could be shifted slightly on the shaft in order to press against the flange and drive the tight pulley directly by this pressure. On the hub of this friction

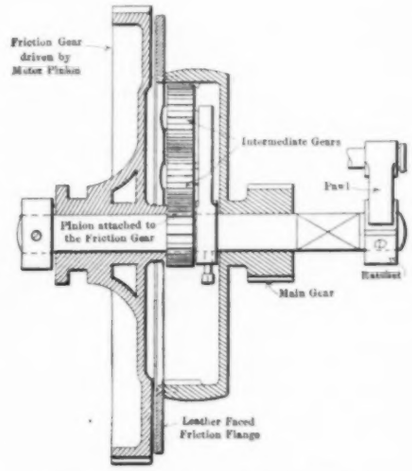


FIG. 2. A TWO-SPEED MOTOR DRIVE

gear was mounted a small spur gear similar to that which had been placed on the slow-speed section of the pulley drive.

When the person operating the machine pulls the shipper to the point which formerly threw the belt onto the slow-speed pulley, the motor switch in the new drive is closed. The motor pinion meshes with the friction gear. When the switch is closed, the motor and large gear immediately accelerate to full speed. The small spur gear on the hub of the large friction gear now imparts a slow speed to the tight pulley through the two intermediates, exactly as was done by the slow-speed section of the pulley drive. The large friction gear, of course, is not now pressed against the leather-faced flange on the tight pulley, but is about one-eighth of an inch from it.

When the operator pulls the shipper farther, to the point where it formerly shifted the belt onto the driving pulley, the switch is left closed; but the friction gear is pressed against the leather-faced flange on the driving pulley and the friction brings it up to the full speed of the gear by a uniform and even transition. The pawl and ratchet are, of course, brought into action in this drive just as with the belt drive. Thus a two-speed drive is effected whose ratio may be almost anything within reasonable limits, and the transition from one to the other, although the ratio be six to one as in this case, is made smoothly and without the slightest damage to the finest threads.

The drive has now been in operation some months on a Draper warper, winding over a thousand threads at a time, and has given good results.

Comparing Horses with Steam Engines

There is a very interesting paragraph in the old book by Oliver Evans on steam engines, which was published in 1801. In those days much of the power for various enterprises was derived from horses, and in order to sell steam engines it was necessary to compare the engines with the work of the horses, with which the prospective customers were familiar.

So in this book we find a rule for this as follows: Multiply the number of horses by 3 and extract the square root of the answer. Multiply this by 1.128 and the answer is the diameter of the cylinder required for an engine having 3-foot stroke and making 36 strokes per minute. The steam pressure does not appear in connection with this rule, but is presumably considered as being the prevailing pressure, which probably did not exceed 10 pounds per square inch at that time, although it was only a few years later when Oliver Evans himself built engines for and advocated the use of 50 to 100 pounds pressure.

Cerro de Pasco, the most important center of the many mining interests in Peru, pays large testimony to the supremacy of American mining machinery. While there are some English boilers and pumps to be found, the vast bulk of hoisting and other machinery used in this district bears American trade-marks.

Two Methods of Making Master Cams

One Cuts Them on a Milling Machine without Laying Them Out, the Other Uses a Blackened Zinc Templet

BY WILLIAM V. LOWE

Whenever it is desired to make cams in any quantity in general the first problem is to provide a master cam to be used in the cam-cutting machine. There is a possible exception to this, if the cam blanks can be threaded on an arbor and milled by a formed cutter. In this case, however, it is necessary to make a templet by which the tool used to make the formed cutter can be tested for outline.

The problem came to me the other day of making a master cam for cams operating the exhaust valve of a gasolene automobile engine. It was proposed to make a cam, harden it and use this as a guide in filing up the engine cams. The cam was of a slightly different outline and timing from those regularly used; consequently the time and expense of making the master cam were relatively important, as there might be only one set of cams required.

After giving a little thought to the subject a method was devised by which the cam was cut on the milling machine and so nearly finished there that a very little smoothing up with a file completed it ready for hardening. After hardening, this master cam and the blank were keyed on an arbor, and the hardened master formed a guide for the file in shaping up the blank.

Laying Out

The first operation in making the master was to lay out the finished cam on a scale four times size, so that the construction lines would not run together and cause confusion. It was not necessary to take especial pains with this layout, since it was used only for a sketch. The cam itself was cut from figures, as will be described. Referring to Fig. 1, the cam is planned to open the exhaust valve 39 degrees before the crank-pin reaches its extreme outer position and close the valve after the crank-pin has passed 10 degrees by the upper or inner center. The inlet valve for this timing of the exhaust opens after the crank-pin has passed the upper center by 13 degrees and closes after the crank-pin has passed 22 degrees by the lower center. The inlet valve, therefore, remains open for 189 degrees movement of the crank-pin, or one-half of this, or 94½ degrees, rotation of the cam shaft. The exhaust valve remains open for 229 degrees motion of the crank-pin, or 114½ degrees rotation of the cam shaft. The lift of the valve is ⅜ inch. The clearance allowed between the roll and the hub of the cam when the valve is closed is 1/32 inch. The diameter of the hub of the cam is 1¼ inches and the diameter of the cam shaft is ¾ inch, with a 3/16 inch key. The diameter of the roll is ¾ inch. With the above data we can lay out a sketch of the proposed cam.

First lay out the angular motion required to open and close the valve, 114½ degrees or 57¼ degrees each side of the vertical center line. Then divide each half into 14 spaces by radial lines, as shown. Lay out the diameter of the hub, above this draw the clearance line 1/32 inch from it and from this lay off the lift of the valve. This gives the highest part of the cam. Draw in the roll tangent to this line, which locates the center of the roll in its highest position. It is desired to raise the valve as quickly as possible so as to get it wide open early in the stroke. If the sides of the cam are made straight lines, as is quite common, the valve will not get wide open until late in the stroke; also a very heavy spring will be required to prevent the roller from jumping off the extreme point of the cam. The cam runs away from the roll, which later strikes the cam a sharp blow under the influence of the spring.

A cam laid out on the curve of uniform acceleration and retardation would be much better. The actual difference between such a curve and the harmonic curve, or crank curve, as commonly called, is so slight that the harmonic curve was chosen. This curve also offers decided advantages from a toolmaker's standpoint, as will be shown. The lift of our cam was to be ⅜ inch and starts from a point 1/32 inch above the hub. To be exactly correct, the harmonic curve should start at this point; however, this would necessitate a double curve, one to give the 1/32-inch lift to take up the clearance, and the other for the lift of the valve. As the cam was quite small, it was thought simpler to have the motion start from the hub and make the total lift 13/32 inch. In order to do this, four extra divisions, the same as those required for the motion of the cam, were laid off at each side.

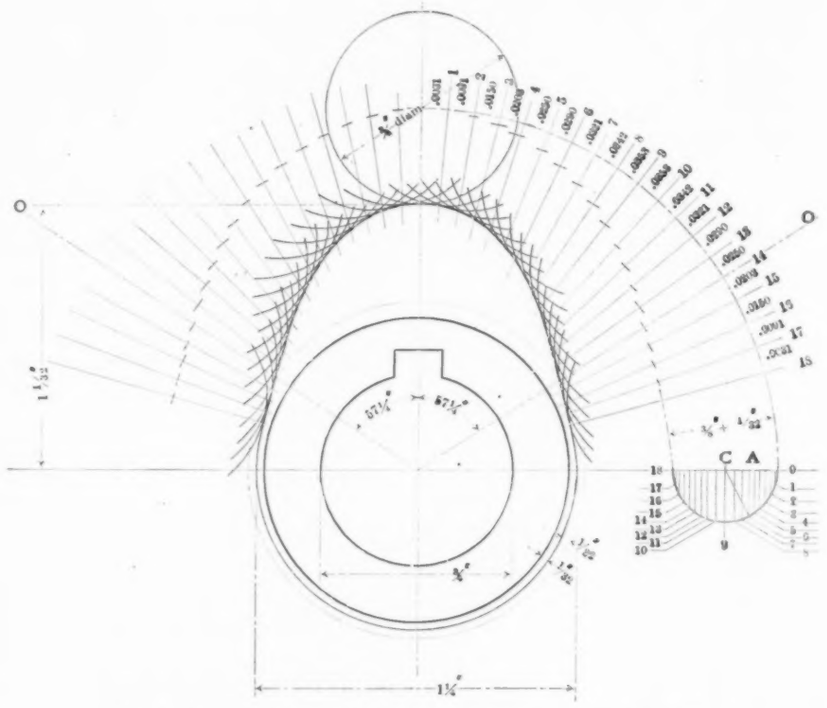


FIG. 1. LAYOUT OF A CAM SHOWING DIMENSIONS FOR MILLING

Therefore eighteen divisions were used, on which were plotted the positions of the center of the roll. The harmonic motion was laid out as shown, and the divisions of the base line, which give the required motion, found and transferred to the various divisions locating the center of the roll. From these centers the roll was drawn in as shown. The half circle used for determining the law of motion was

divided into eighteen parts; each division, therefore, represents 10 degrees of the circumference. If we imagine these divisions joined by lines to the center, it is readily seen that the distance from the point where the vertical cuts the base line to the center is the cosine of the angle, as shown by the line drawn from the point 6, where *A C* is the cosine of the angle *O C 6*.

The method of obtaining the dimensions locating the center of the roll in its different positions is readily seen. All that is necessary is to calculate the cosine of the angles from 0 to 9 and use the figures thus obtained in milling the cam. If the radius of the circle *C-6* was unity, we could use the figures taken from a table of natural cosines. The actual length of these lines is in the same ratio to the figures in the table as the radius *C-6* to unity. We therefore had to multiply the figures in the table by the actual length of the radius *C 6*. The distance *O-18* is 13/32 inch, or 0.40625 inch, and the radius *C O* is one-half of this, or 0.2031 inch. Multiplying by the cosines found in the table gives the actual lengths of the base lines, as shown in the table Fig. 3. They are calculated only to 90 degrees, as then the figures repeat in reverse order.

The Milling Operation

The actual method of milling the blank was as follows: It was convenient to roughly lay out the cam full size and, transferring the outline to the blank, cut away the stock to within 1/16 or 1/32 inch of exact dimensions. It was keyseated as shown and pressed onto an arbor having a key. The arbor was held in the index head of the milling machine with its spindle facing the milling machine spindle. The machine spindle carried an end mill of the same diameter as the roll to be used on the cam; in this case ¾ inch diameter. From our diagram we know that the radius of the highest part of the cam was 1 1/32 inch. The blank was moved up to the cutter and vertically under its center, as shown in Figs. 1 and 2. Care was taken to get this distance correct as well as the relation of the cutter and work.

The plan called for 14 spaces in 57¼ degrees, or 4.09 degrees per space. Dividing 360 degrees, the entire circle by 4.09 gives 88 spaces; so we put on an index for 88 teeth. After starting the cut at the apex, we drew the work back and indexed ahead one tooth. Turn to the table, Fig. 3, and note the column headed "differences." These are the amounts which the milling table was moved for each hole of the index. After indexing to the second hole the table was moved 0.003 inch and the work fed against the mill for the second cut. In this manner the work proceeded until 18 cuts were made, indexing for each hole and moving the table the amount shown by Fig. 3. After 18 holes, the table was left stationary and the work moved around by the index head for 52 holes. Then the table was moved down according to the figure in Fig. 3, indexing one hole each time.

The milling cutter works better if used as an end cutting mill and the work fed on to it endwise. It also means fewer movements on the machine.

After going over the blank as described, it was found to be covered with slight ridges separating the different cuts. A very little work with the file smoothed these down, the result being a cam nearer to the original plan than if made with ordinary toolmaking and laying out full size.

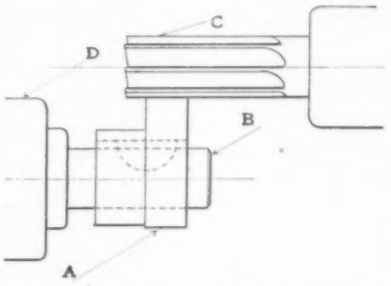


FIG. 2. ARRANGEMENT OF CAM BLANK AND MILLER CUTTER

The actual operations were much simpler than would be thought from the description. We found the result very satisfactory indeed and it was secured in less time than would have been the case if laid out and finished in the usual manner. In milling there should be made out a table of the differences or amounts to move the table for each cut. Then it is simply a question of a little care and checking off the figures to get good results. It is not unlikely that this method might be used on cams of large size.

Angles.	Natural Trig. Cosines.	Actual LengthCos.	Differences.
0	1	0.2031	
			0.0031
10	0.98481	0.2000	
			0.0091
20	0.93969	0.1909	
			0.0150
30	0.86603	0.1759	
			0.0203
40	0.76604	0.1556	
			0.0250
50	0.64279	0.1306	
			0.0290
60	0.50000	0.1016	
			0.0321
70	0.34202	0.0695	
			0.0342
80	0.17365	0.0353	
			0.0353
90	0	0	
			0.0353
100	0.17365	0.0353	
			0.0342
110	0.34202	0.0695	
			0.0321
120	0.50000	0.1016	
			0.0290
130	0.64279	0.1306	
			0.0250
140	0.76604	0.1556	
			0.0203
150	0.86603	0.1759	
			0.0150
160	0.93969	0.1909	
			0.0091
170	0.98481	0.2000	
			0.0031
180	1	0.2031	

FIG. 3. DIMENSIONS USED IN MILLING.

A Common Method

In many cases of large cams it is customary to make a lay-out on zinc. This is filed up by a careful man and used as a templet for making the leader. The zinc is soft and a false stroke of the file may spoil the lay-out. It is also expensive in time and money. At one shop where I worked we made an improvement over this process. First we had a large sheet of zinc blacked. The recipe is old and generally well known, but in case anyone is unfamiliar with the process I will give it here:

Recipe for blacking zinc to use for templets: Four ounces sulphate of copper (blue vitriol); 1 pint of water; about 10 drops of nitric acid. Clean the zinc from oil before coating, then pour the solution over it and distribute it with a piece of waste. The color is governed by the nitric acid. Add acid until the color is right. After blacking rub the surface with an oily rag. This makes the color a more intense black. It should be dead, without luster.

After the sheet was coated we had it cut into pieces 12 inches square and kept there in the drawing room. Templets were laid out on these pieces, each one given a number and kept in envelops in a drawer in the drawing cabinet. A record of them was kept in the card catalog of drawings. After the master cam or leader was made, the templets were left in the drawing room for future reference. The cams were laid out by a draftsman using regular drawing instruments as a rule. Care was taken to locate properly the center of the cam roll and lightly center punch it.

In the shop the templet was indicated in the lathe and a 1-inch hole made in the center. A blank was then made and roughed out a little over size. This was usually a piece of cast iron about ⅝ inch thick. The leader had a 1-inch reamed hole through it. A flat piece of iron with a hole through it large enough to pass over the 1-inch arbor was placed on top of the jaws of a vise. The arbor was passed through the templet and held in the jaws of the vise, the templet resting flat on the piece of iron.

The leader was now passed over the arbor and slipped down till it rested flat on top of the templet with a piece of paper between. It should be understood that the templet, with the exception of the 1-inch hole, is in the same condition as when it was first laid out. The upper surface of the leader has been coppered. Now take a pair of dividers, with one leg as much longer than the other as the thickness of the leader. Place the point of the long leg in the various center-punch marks, which indicate centers of the roll on the templet and set to the radius of the roll. The circles of the roll are then transferred to the leader. The leader is then taken to a milling machine and milled down as close as possible to the

line, and finished by hand. The leader can be lowered on to the templet, and it is easily seen when the two correspond.

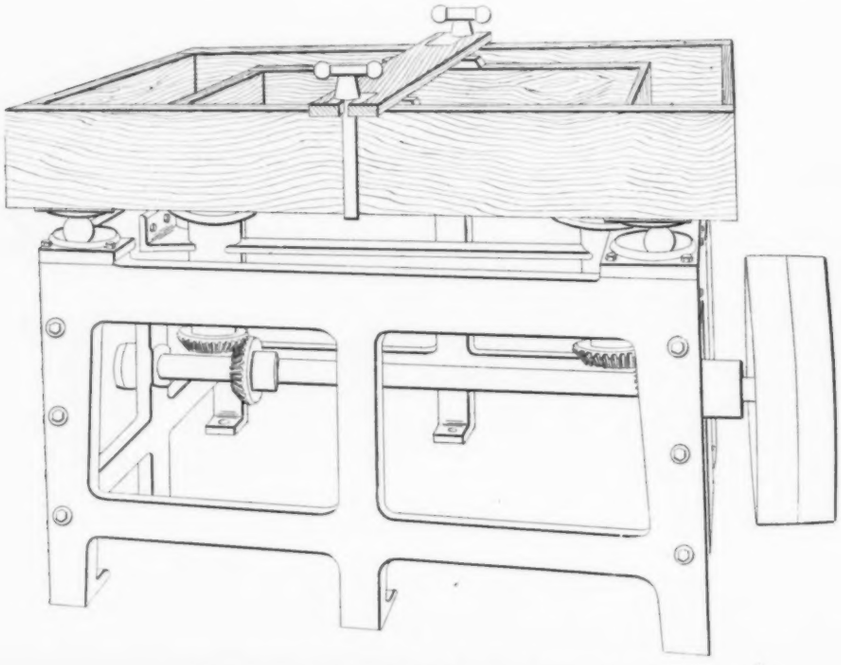
The advantages of this method are: The black zinc gives good clear lines to work to; the original lay-out is not disturbed a particle, and may be referred to at any time; there is considerable time saved over that required to file up the templet.

This method is used with entire satisfaction in the shop where it originated. Should it ever be required to file two thin pieces to match exactly, as is often required in making templets, have a piece of good plate glass to use as a support while holding the pieces to the light to see how close they are. I learned this from a Pratt & Whitney toolmaker over 20 years ago, and have been surprised to find it is not more generally known.

A Novel Ball Bearing

Plates of zinc or aluminum used for lithography are first treated to a graining process which gives them the surface required for this work. This is done by clamping the plate in the bottom of a tray, covering it with sand and agitating the whole mass so that the grains of sand move on the plate.

One of these machines is shown with this in order to illustrate a novel application of balls to a bearing. The tray is agitated or wabbled by two short throw cranks driven by the bevel gear underneath so that everything has a rotary motion. At the four corners of the frame are pockets, flat plates with raised circular edges and in each of these is a 2-inch steel ball. The upper plate is perfectly flat and the balls give a perfect rolling motion as the tray moves through its small circle. The application is different from those usually found and answers the purpose admirably. It is made by the Potter Printing Press Company, Plainfield, N. J.



A NOVEL BALL BEARING APPLIED TO A GRAINING MACHINE

Individual Lighting for Machine Tools

By H. P. Fairfield

An editorial on shop lighting, on page 638, as well as a recent allusion to the methods employed by a drop-forging company to light its large machines by wires from below the floor, leads me to furnish illustrations showing how the machine tools in the shops of the Worcester Polytechnic Institute are lighted.

During the winter of 1906 plans were matured for considerable changes in the shops; in common with other matters concerning the proposed changes, the subject of lighting the machines was carefully considered. The system so common in shops, of dropping from the ceiling flexible cords with pendant incandescent bulbs and metal shades, had been in use for several years. This method had proved most unsatisfactory in lighting work and machine, and in its appearance. In using the light it was, in most cases, necessary

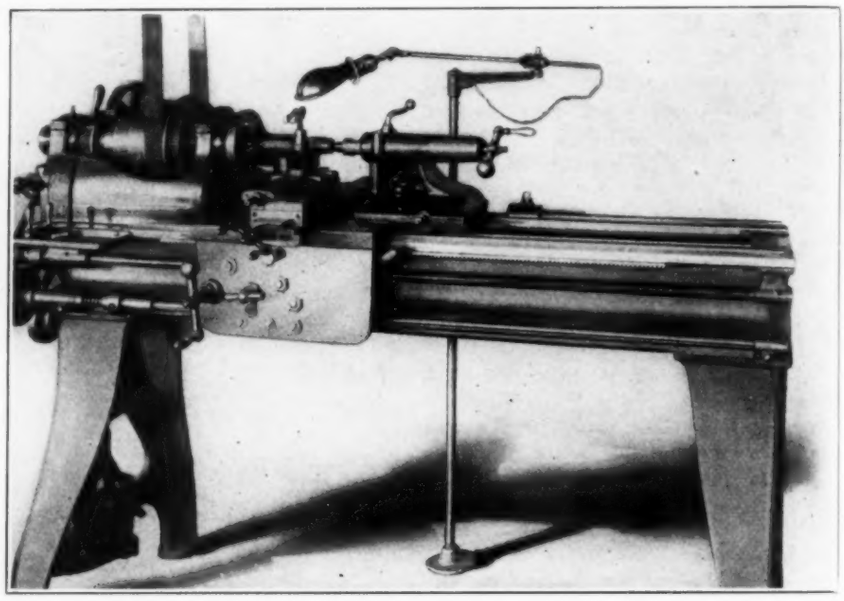


FIG. 1. LIGHTING FIXTURE FOR A LATHE

to hold the light in some other position than the place where it naturally hung; or if the operator had use for both hands at his work, he tied the lamp to some part of the machine or to a post, or in fact to any object that would help bring the light nearer the point desired. The result was a network of cords, strings and weights that were sure, sooner or later, to get tangled in the belts or moving parts of the machine.

After trying various schemes, the one shown in Figs. 1 to 5 inclusive was installed as the best solution of the problem. This does away with the difficulties spoken of, brings the light into any position desired for use, holds it in this place until the operator is through with it, and can be readily swung back out of the way when not in use. In fact it is so completely convenient that the workman reaches out to it as instinctively as he does to any of the adjustments of his machine and without looking up from his work. The clam-shell shade protects his eyes from the glare of the filament and gives an intense illumination where it is

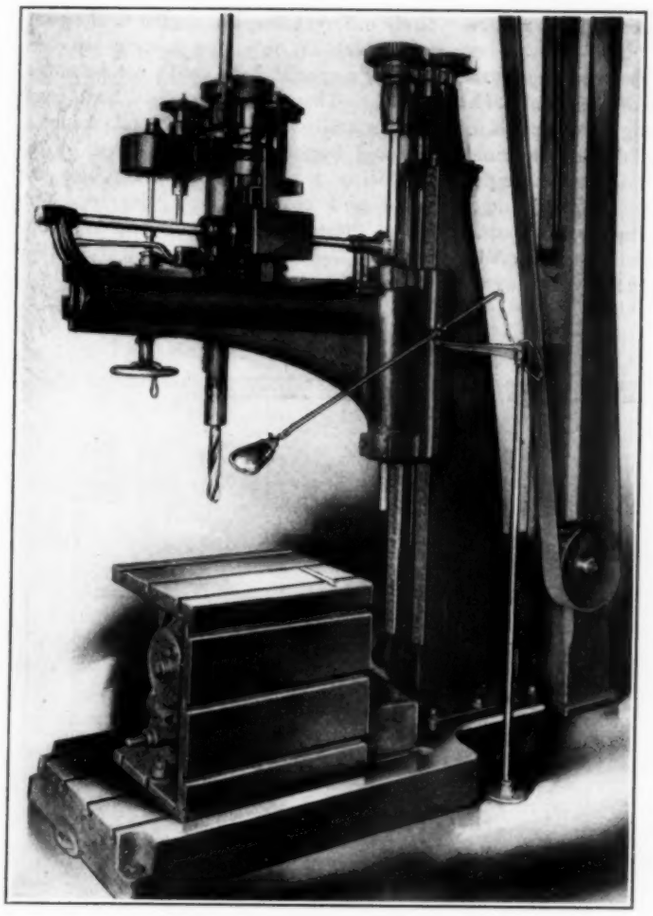


FIG. 2. A LIGHTING FIXTURE FOR A RADIAL DRILL

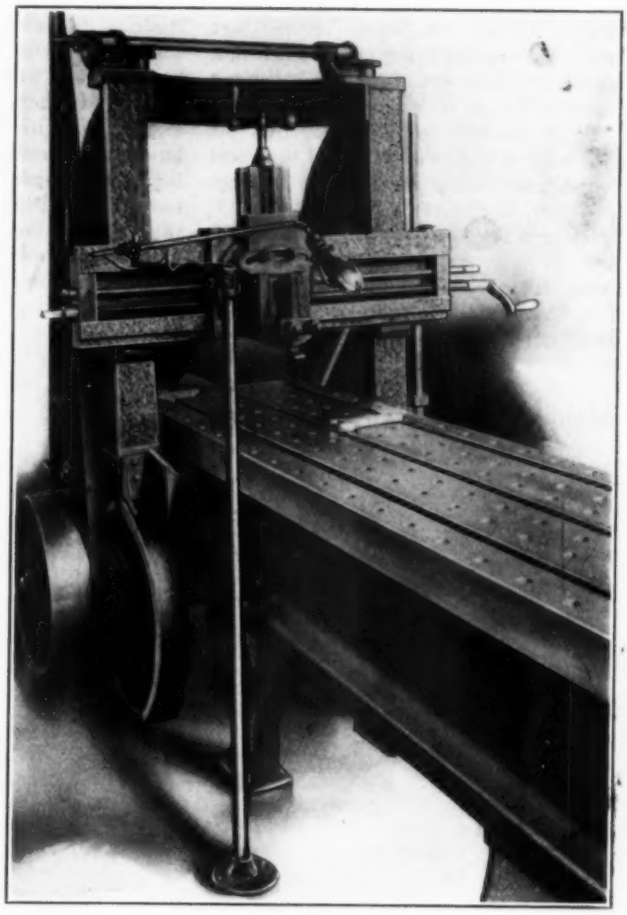


FIG. 4. A LIGHTING FIXTURE FOR A PLANER

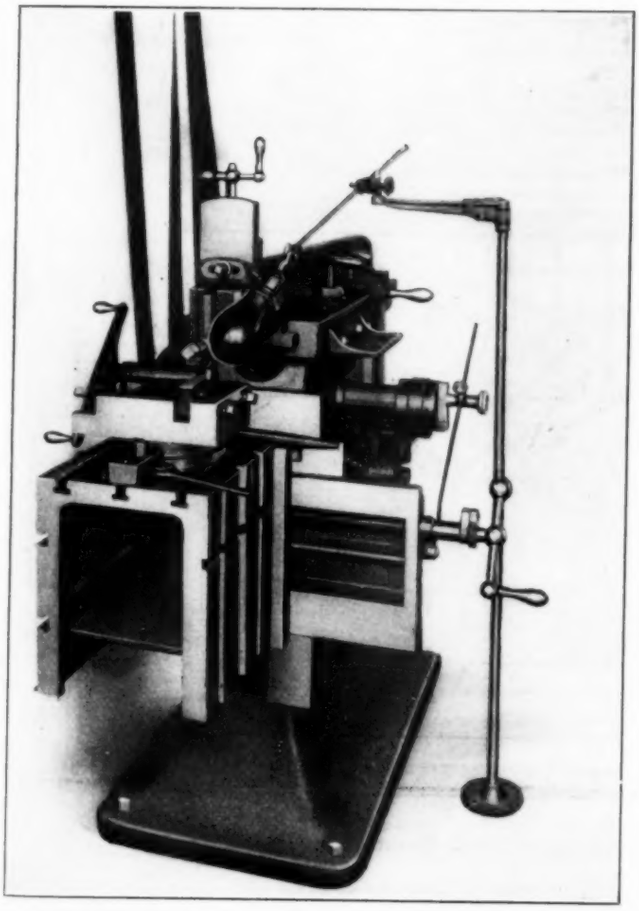


FIG. 3. A LIGHTING FIXTURE FOR A SHAPER

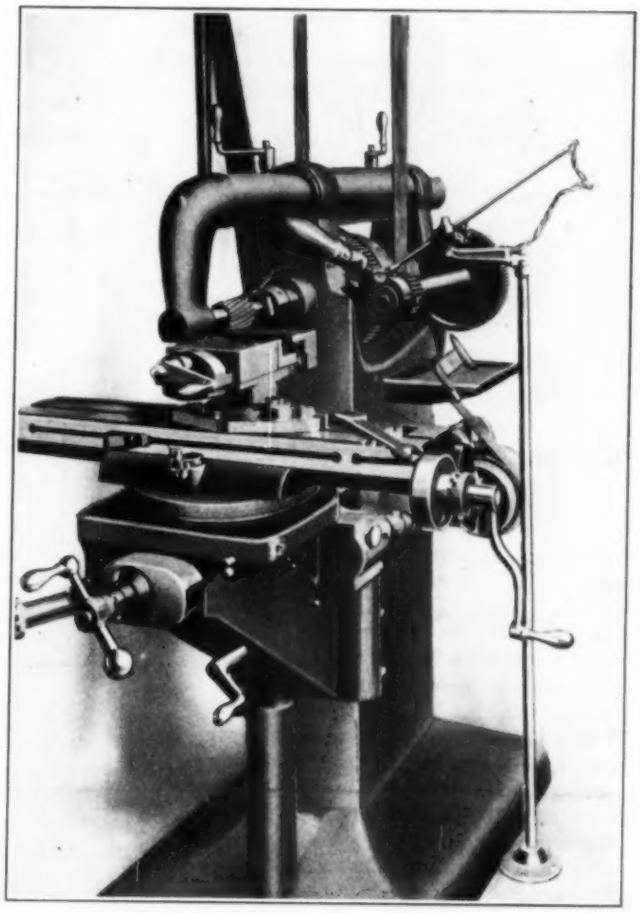


FIG. 5. A LIGHTING FIXTURE FOR A MILLING MACHINE

desired. Then, too, where before there was a constant replacing of broken lamps, breakage is now unusual. The half-tones illustrate its use on various machines.

In all cases it will be noted that the feed wires are on the ceiling of the room below, and connection is made through the floor, the wires passing up to the crank arm and lamp arm through conduit pipe, to meet the underwriters' specifications. The individual lighting is so perfect that exterior light conditions are never noticed by the workman.

Molding a Four-way Stand Pipe

By George Buchanan

In Fig. 1 are shown plans and part sectional views of a four-way standpipe.

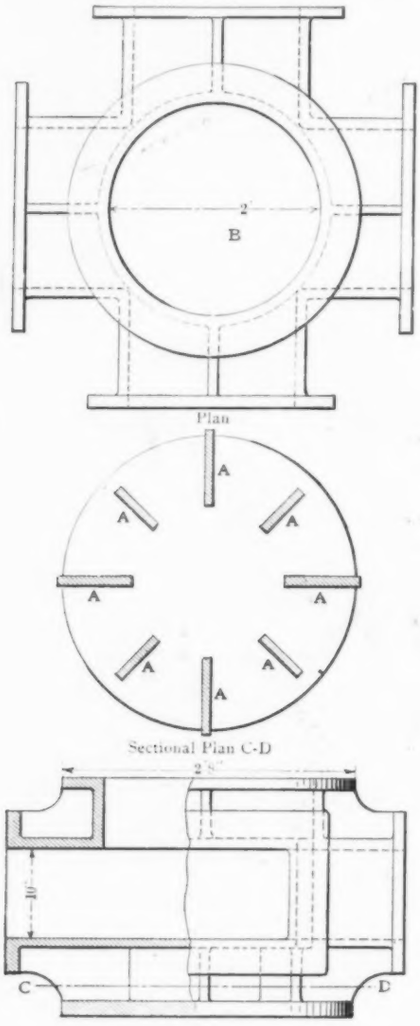


FIG. 1. FOUR-WAY STAND PIPE

This pipe forms rather an important part of a sewerage system and consists of four oblong flanged branches opening into a circular body flanged at the top and having a stand attached to its base by means of eight ribs. These ribs are shown on the sectional plan at *A*. In the present instance, as stated, four branches are required, but frequently three, or even two branches are used, depending upon the position of other parts of the plant. The method used in molding this pipe is of interest, illustrating, as it does, the molding of a four-part pattern in a three-part box. The method of molding depends on the fact that the molding box is a stock one, having been made for a pattern of about the same size generally, but of entirely different shape in regard to the parting lines; as only one casting was required, a special flask could not be entertained. This piece weighs about 2000 pounds and is made in dry sand, the middle and bottom parts being fired by introducing a circular fire grate into the mold and covering over the top with metal sheets, the drawback and top parts of the mold being placed in the oven over night.

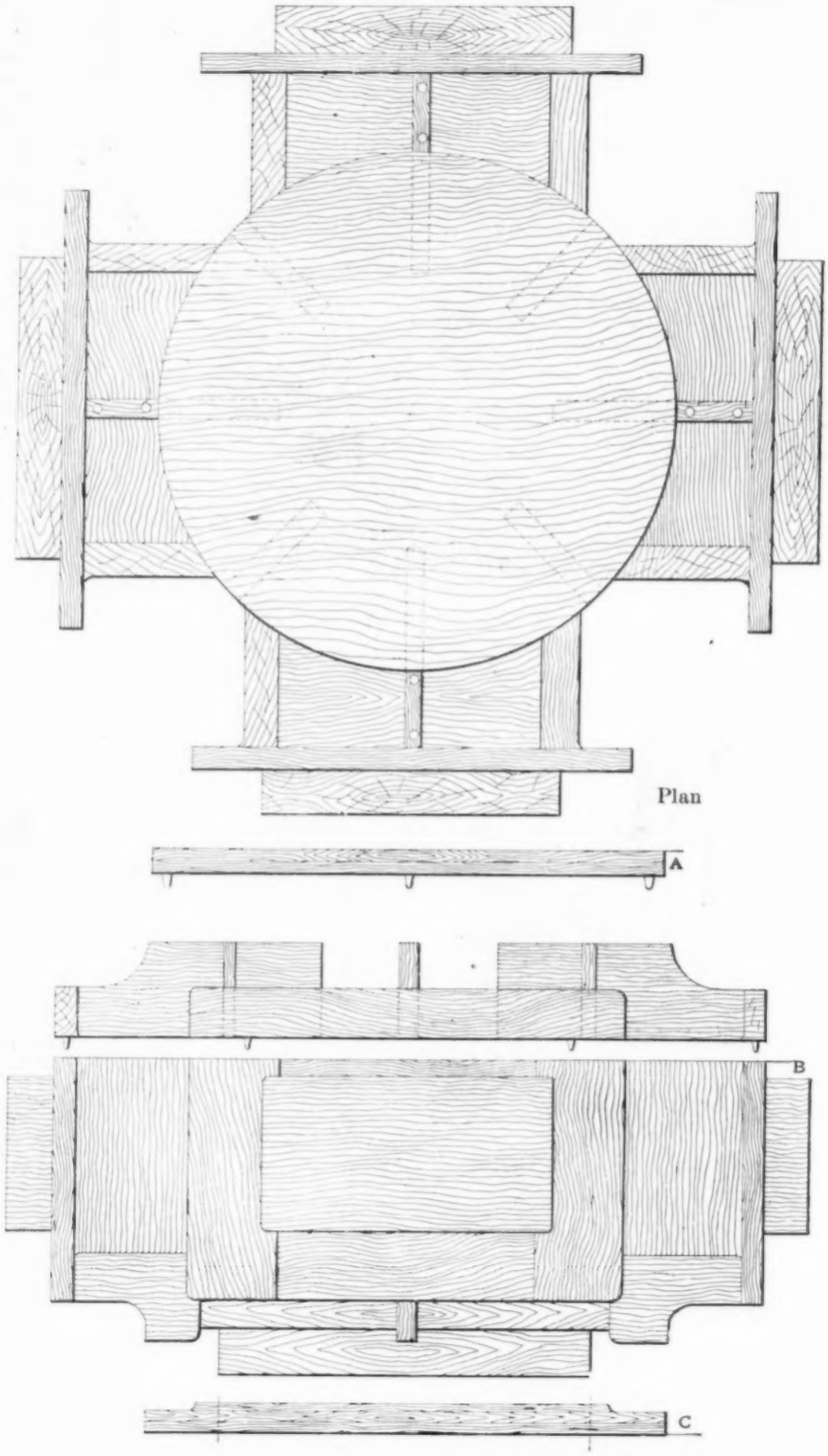


FIG. 2. THE PATTERN

The Pattern

Fig. 2 is a plan and front elevation of the pattern. On the elevation the various partings of the patterns are shown, the pattern being shown apart at the joint lines. *A*, *B* and *C* are the parting lines of molding.

Fig. 3 is a sectional view of the mold complete, all cores being set and the drawback and top parts being shown lifted away. This gives a simple view of the parting of the mold.

The Molding Process

The actual molding of this piece is as follows: The cope is laid on the floor on its back and roughly filled in with floor sand and struck off level. The pattern is then placed on the bed and the middle part of the flask located. The mold is rammed up in the usual way, no notice being taken of the parting *A B*, Fig. 3; but the mold is simply rammed up as if there were no partings until the joint *H* is reached. Of course the back of the circular flange is well ironed; after the joint is made, the nowel is rammed up and lifted off. It will be noticed that the bottom box is barred in exactly the same manner as the top part; this in the present instance facilitates the lifting off of the drag so that the circular flange pattern can be rapped and withdrawn from the mold, which is then finished and blackened and the drag part returned to place. If the drag part were flat barred, as is often the case, it would then be necessary to make a loam cake to cover the flange face; but as shown, this is not required.

The various parts of the mold are next clamped together; by means of the swivels *H H* and a beam, the whole is lifted and turned over in slings, the swivels being just in the right position

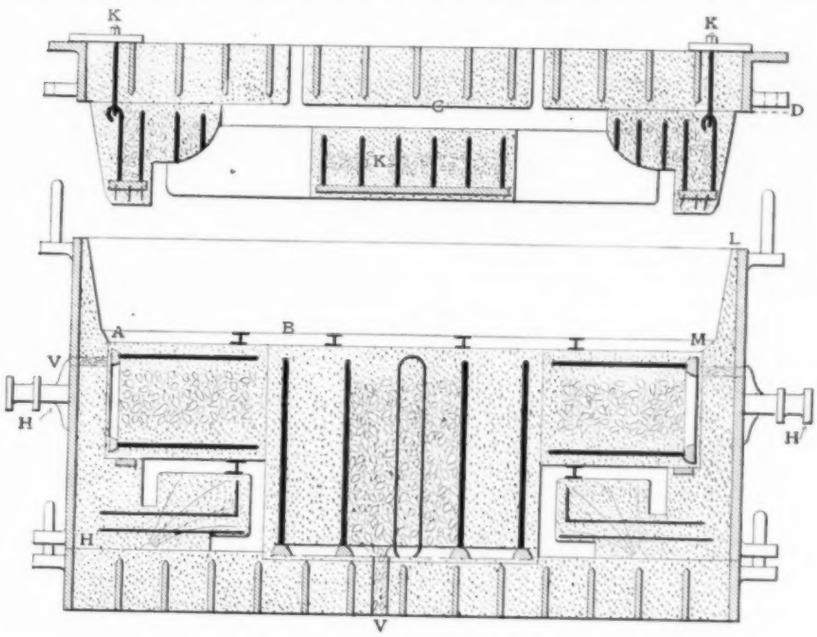


FIG. 3. VERTICAL SECTION OF THE MOLD

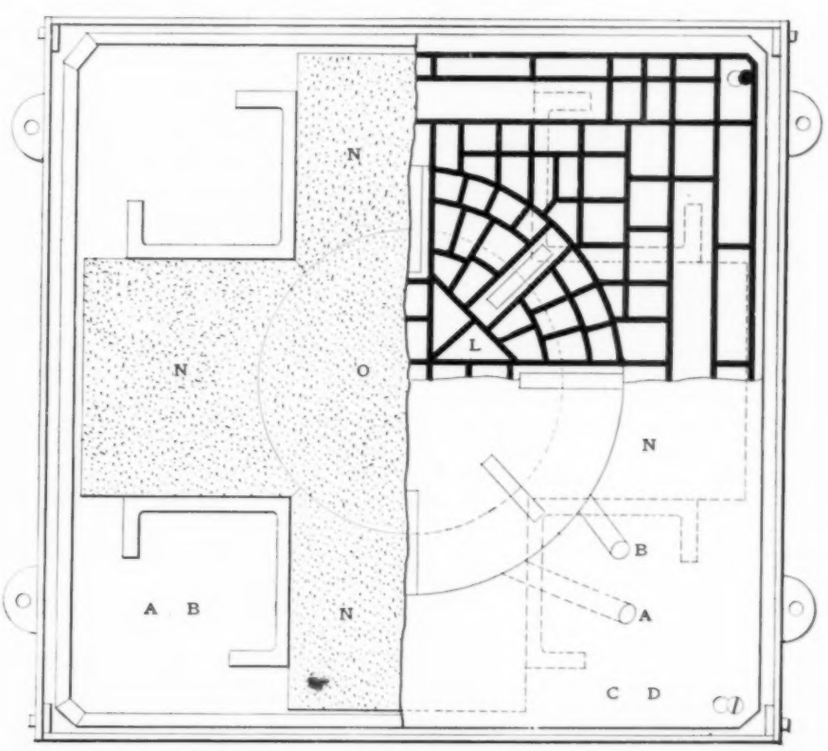


FIG. 4. PLAN OF THE MILL

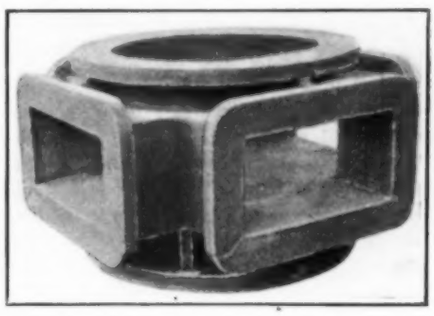


FIG. 5. THE CASTING

to balance the whole. The mold is then lowered carefully onto a prepared bed of sand and the mold rubbed down a little so that the bottom of the mold finds a good solid bed on the floor. The cope is next lifted off and the joint made down the side of the mold, as at *L M*. Wet parting sand having been sleeked on the inclined joint, the core iron is next placed on about half an inch of core sand; this part is rammed up, vented and a train of cinders laid in trenches between the ribs, as shown in the mold at *K*, Fig. 3. Referring to Fig. 4, which is a plan of the mold complete, *A B* is on the line of parting which has just been made, while *C D* shows the joint at the top edge of the circular foot. A quarter of the core iron which carries the drawback is shown at *L*. At *C D* runners *A* are shown entering into the circular flange in the bottom of the mold, while *B* enters the circular foot at the top of the mold. The *A* and *B* down gates are brought into the same pouring basin, and by means of stoppers the metal is let into the gates as required.

After the core or drawback has been rammed up, the circular foot is bedded on, it being located on the eight ribs by dowels. A joint is then made at the top edge *C*, Fig. 3. The cope is next lowered on, rammed up and lifted off; the circular foot pattern is drawn out, also the eight ribs. This part of the mold is blackened and the top part returned to the joint.

Four hook bolts are next attached to staples cast in the drawback core iron, shown at *K K*, Fig. 3, and the drawback secured to the top part by these means. The cope and drawback are then lifted off, turned over and finished; the pat-

tern is drawn out of the bottom, which is also finished and fired as before mentioned.

The Cores

The cores do not present any unusual features, one box only being necessary. This core box is used four times for the cores *N N N N*, Fig. 4. A strickle is used to form the center core *O*. The gases from this core are led off through the bottom of the mold at *V*, Fig. 3. The points of the side branch cores *N* are supported by chaplets. A glance at the sectional side view, Fig. 3, will be better than any attempt at explaining this part of the coring.

All cores being set, the thickness of metal is noted, when trying on the cope, by means of clay, chaplets being placed in place of these pieces of clay and the top lowered on. It only remains now to cotter the mold by means of four cotters through the guide pins and make up the runner basin to complete the mold. Fig. 5 is a half-tone of the casting.

The Treatment of High-speed Steel

By Ethan Viall

I believe that a great many get the idea that the treatment of Novo steel is the right treatment for all high-speed steels. In fact I have heard all kinds of high-speed steel dubbed "Novo," just as if it were a synonym for high-speed steel and not the name of a special brand.

There are hardly any two makes of carbon steel that can be hardened in exactly the same manner with satisfactory results, and many times two rods of the same make vary greatly. At one time I had a bar of 4-inch Jessop cast steel 6 feet in length. This was cut up into disks ¾ inch thick for the making of forming tools. At one end these tools hardened readily at a low red, but at the other they had to be heated almost white.

Hundreds of toolmen have undoubtedly had the same sort of experience. Now if so much variation is found in carbon steel, why try to make one sort of treatment serve for all brands of high-speed steel? It is not reasonable and practice shows that the facts bear out this theory.

Some of the writers have insisted that all high-speed steel must be brought to a fusing heat and air cooled; others insist on oil cooling. Many declare that no high-speed steel should be cooled in water. This last is true of some brands, Novo included, but there are some brands of high-speed steel made expressly for water cooling. This will probably come as a surprise to some, but a glance at several well known catalogs will reveal the names of this kind of steel regularly listed.

Many bars of good high-speed steel are thrown away through ignorance of the proper treatment. Perhaps the hardener has been taught to heat the tool till the point runs, and he proceeds to treat everything but carbon steel in this manner regardless of the directions sent with the steel.

Forging

Probably more lathe and planer tools are ruined in the forging than in the hardening, but take the two together and the result is often discouraging.

A man used to regular blacksmith work, that is, working iron, is a poor man to put on forging carbon steel; the ordinary toolsmith used to carbon steel is equally bad when forging the average high-speed steel, though a few brands of high-speed steel require almost the same treatment.

With Novo steel and steels of that class great care is required to keep the right forging heat, as too little will cause the steel to check and crack, while too much will make it crumble.

Heating high-speed steel to certain exact temperatures for hardening is only applicable to well equipped shops and not to the "little fellow." We employ nine hundred men in our factory, probably seven hundred of whom use high-speed steel tools of some kind; our hardening plant is one of the best equipped in the West, but a great deal more dependence is put upon the skill, experience and judgment of our hardeners than upon the pyrometers.

A Curious Case

As an illustration of the illusiveness of the hardening qualities of steel, let me give an instance that happened to the Simonds Saw Company. A number of crucibles of exactly the same mixture of steel were run out, and it was found that the steel from the fourth crucible would not harden. This occurred several times and at last it was found that this crucible was so placed that the jar from a large steam hammer affected it more than the others. No chemical change could be detected—the change was apparently a physical one. The steam hammer was moved to a distant building and no further trouble ensued.

Now to come down to the exact hardening treatment of high-speed steel, no general rule can be given that will apply to all; the most sensible way is to do as near what the makers recommend as we can, varying it for our individual needs as little as possible to get the result we want.

Styrian Steel

Taking up separately the various brands of high-speed steel, let us first see what the makers of Bohler's Styrian high-speed steel say is the proper way to harden their steel; we will at once see that the "heat the point till it runs" man would do irreparable damage to it.

"Directions for hardening lathe, planer and boring tools: Heat to a white heat but not to a scaling or melting point—just a good white heat. Cool in the air or cold blast.

"For forging: Heat to a bright yellow. Do not allow the heat to run as low as a cherry red, while forging. After forging allow tool to cool slowly before hardening." How few follow this last advice.

"For cutting off: To avoid cracks, etc., heat the bar slowly and carefully. Nick while hot and break off required lengths while cold.

"For hardening milling cutters, taps, reamers, twist drills, etc., heat as for lathe tools and cool in fish oil."

Boreas Self-hardening

The above applies to the brand known as rapid self-hardening; for Bohler's Boreas self-hardening, the treatment is a little different:

"Forge at a cherry red, *not more*. Care must be taken to heat the steel slowly and uniformly. Blast should not be employed after the steel has become dark red, but it should remain in the fire until thoroughly heated, so as to be quite ductile under the hammer. The tool should be forged and finished off at a good heat. The steel should be heated several inches higher up than it is required to be forged. If the material to be cut is exceptionally hard and the speed very high, the following instruction ought to be observed. When the tool is forged it should be placed in a strong cold blast when at a dark red heat. If this is not convenient, the tool should be placed in a strong current of air—water must not be used."

"Ark" High-speed

So much for Styrian steels; now for Jessop's "Ark" high-speed steel:

"1. Cut the length of tool required from the bar while hot. Do not break cold without nicking, nor forge a tool from end of bar broken off cold.

"2. Heat the steel to a canary color, retaining this heat until tool is forged as near as possible to shape required. The tool may be rough finished by grinding while yet hot, on a dry emery wheel. It should then be laid aside in a dry place until black.

"3. First see that there is a clear fire and plenty of coke covering the tuyere, so the fire will not burn itself out before the tool is brought to the required heat. Without this body of fire between the tuyere, the blast will strike the tool which will oxidize and show deceptive appearance of proper heat necessary to good results.

"Unless coke is used, the ordinary fuel burns out too rapidly. Place the nose of the tool in a clear fire. Slowly heat the steel to a white or welding heat, not over one inch from the end. The nose of the tool should be fusing hot. Then the nose of the tool should be placed under a strong, cold, dry-air blast until cold.

Some prefer oil to air hardening altogether. Any good oil may be used; but it should be thin—not heavy nor gummy.

"While steel is hot water should not touch it.

"The tool when thoroughly cold is ready for grinding, which should be done on a wet emery wheel with plenty of water. It is important to use plenty of water, because a dry emery wheel heats the steel to the point of annealing on the cutting edge, at the same time the heat is not high enough to bring out the hardening qualities of high-speed steel. Hence even tool-holder sizes should be so treated.

"The above directions do not apply to such tools as reamers, taps, etc., or when such high heat would interfere with shape or size of tool. These can be got hard enough for the uses they are put to by heating to a light yellow and plunging in oil, keeping it away from the air as much as possible to avoid oxidation."

Bethlehem Self-hardening

For Bethlehem self-hardening steel the directions are:

"Forging: Heat slowly and thoroughly to bright cherry red, merging into full yellow. To avoid checks at sharp corners which weaken the tools, no forging should be done below a cherry red.

"Treatment of roughing tools: Heat the tool slowly to cherry red, then bring the cutting portion of the tool to a white heat as rapidly as possible, in a soft coal or coke fire, and then place immediately in a dry cold-air blast until cold.

"Care should be taken to provide a good bed of fuel so that the blast does not blow through and strike the cutting edges of tools. Finished machined tools are hardened by heating uniformly as hot as possible without injuring or deforming the shape and then cooling in air or oil, oil being preferred."

As directions for annealing this steel were omitted from my article in the American Machinist, Vol. 30, page 299, I will give them here: "Bethlehem self-hardening steel is annealed by being heated slowly and evenly to a bright cherry, then buried in dry warm lime. The lime can be warmed up with heated fire bricks before the bars of steel or tools are buried in it. Where a large number of bars are to be annealed, this is best done by heating them in a furnace to a bright cherry red. The furnace is then luted up and allowed to cool down with the bars. The bars should not be nicked nor broken when cold."

Capital High-speed

"Capital high-speed steel is forged at an ordinary red heat. Re-heat rather than hammer when too cold; it will not injure the steel. To harden: Bring the point of the tool to a white melting heat. Plunge the whole tool in oil until cold. An air blast may be used instead, but must be used intelligently."

The makers of the above steel list what is known as D. S. W., high-speed water-hardening steel, specific directions for hardening which are not at hand.

Crescent Self-hardening

For Crescent self-hardening steel: "This steel should always be cut off hot or nicked deeply while hot and then broken cold. Forging should be done at a good bright heat. All heating should be even, thorough and well distributed. If forged below a red heat, fine cracks will develop. After the tool is shaped, re-heat to a full bright red approaching yellow, and cool in a dry place.

"If lathe tools are found to be too hard under this treatment, the nose of the tool may be ground or brightened and then held over the fire until light blue appears. When it can be cooled in the air, or after the last heating, the tool can be 'tempered' by being placed in the ashes on the forge until it cools to medium red, when it may be cooled down cold in the air. Never dip the steel in water or any other liquid when hot."

This is one of the few high-speed steels that the makers say can be "tempered" and is also one which does not readily take to the oil bath.

Midvale Special

The Midvale Steel Company's directions are:

"For Midvale special self-hardening steel heat to white heat and cool under forced blast till all color has disappeared from the head of the tool."

For the above steel in taps, milling cutters, etc., "first gently warm the piece to remove any chill. Next heat it slowly and evenly to a dark cherry red, not scalded, in a covered fire or by preference a gas furnace; then immerse it in white-hot lead. In from one-half minute to three minutes, depending upon the size of the piece, it will have attained the temperature of the lead; then quench it in oil for about half the time it was in the lead, until on putting it on a dry board to cool, the return of heat to the surface will not make it show colors. To harden properly and not crack the tool, the lead must be as hot as possible and care taken that the piece neither goes to the bottom of the oil tank, where there is often a collection of water, nor is set down in a damp place until thoroughly cold.

"Where punches and similar tools are to be hardened for a portion of their length, care must be taken not to immerse the piece in the oil beyond where it shows a bright red color, as it is apt to crack if dipped at a low heat."

Blue-chip Steel

For the old, well known blue-chip steel the Firth-Sterling Steel Company says:

"For this steel a good fire is one made of hard foundry coke, broken in small pieces, in an ordinary blacksmith forge, with a few bricks laid over the top to form a hollow fire. The bricks should be thoroughly heated before tools are hardened. Hard anthracite coal may be used very successfully in place of coke and will give a higher heat.

"In forging do not hammer steel after it cools below a bright red. Avoid as much as possible heating the body of the tool, so as to retain the natural toughness in the neck of the tool.

"To harden, heat the point of the tool to an extreme white heat until flux runs. This heat should be the highest possible short of melting. Care should be taken to confine this heat as near to the point as possible, so as to leave the annealing and consequent toughness in the neck of the tool. Cool in air blast, the open air or in oil. Grind on dry wheel."

Allen's High-speed

In the little booklet issued by E. R. Kent & Co., I find these directions for Allen's high-speed tool steel:

"Forging: Heat steel slowly, thoroughly and evenly to bright red, shape tool, allow it to cool, then grind to shape.

"Hardening: Re-heat cutting edge of tool while hot. Cool in air blast. The more quickly the steel is cooled the better results are obtained.

"If you have no air blast, the steel can be cooled with excellent results in water at a temperature of about 150 degrees Fahrenheit, or in oil at about 80 degrees Fahrenheit. In no case must this steel be carried, after heating to a white heat as described, to any distance, and we would advise you if your air blast is not close at hand to use water or oil as directed.

"What we mean by white heat is that the steel should sweat or blister, and these blisters should be at least 1/16 inch in diameter to give good results. Grind tool on wet grindstone."

As to hardening of Novo, I think the directions are too well known to need repeating.

Burgees No. 5 Special

With Burgees No. 5 special, I obtained the best result for our own use as thread tools and regular turning, where a finer point was required than could be maintained with Novo, by heating the point of the tool to a nice even white, then cooling in an air blast till color died out, then plunging in oil. In this way the steel would hold a point almost indefinitely in tap cutting at ordinary speed and gave very satisfactory results in regular turning at high speed.

Conclusions

As a rule I do not believe in using more than one brand of steel, if it can possibly be avoided; but if it is necessary, then the steel should be painted some distinctive color as soon as received and anything made should be stamped with the name of the steel of which it was made.

Finally I want to quote a short piece from Arthur Balfour's "Hints":

"With high speeds the shape of the tools is of great importance, on account of the heavier strains to be endured. Round or square-nosed tools are advisable rather than sharp-pointed tools. It is not possible to lay down definite rules, as experience has shown that conditions vary so much that the individual machinist is the best judge of the shape of tool most suited to his particular work.

"In most cases high-speed tools should be made stiffer than those of ordinary carbon steel, and sharp angles should be avoided.

"The larger the section of steel used, the more heat it will absorb and carry away from the cutting point; and on this depends the life of the tool.

"Tool holders are not recommended. The small tools they hold, even if very well fitted into the holder, cannot disperse the heat generated by fast cutting like a solid tool."

Some Applications of Autogenous Welding

By W. I. Reich*

The oxy-acetylene autogenous welding process found a large field in a number of manufacturing establishments. It is most commercial in shops, where there is a large variety of work. It can not compete with multiple machine riveting or with expensive coke and gas welding installations.

The objection to a coke welding installation is the high first cost, and the injurious oxydizing effect, due to the long exposure of the hot metal to the atmosphere.

On the other side, a gas welding installation is only suitable for very large shops, due to the high cost of the gas generators, gas holder, power hammers and presses.

The problem in all welding operations is to work the hot metals rapidly, or to heat only a small section at one time. The oxy-acetylene process will furnish the right temperature for fusing the metals, without oxydizing the joint.

Heat Metal before Welding

The trouble that might arise, in this welding process, is that the metal is too rapidly chilled, which would tend to weaken the joint.

This difficulty can be overcome by heating the metal before welding; in which case we gain both better efficiency of the joint, and higher speed in welding. It is advisable to cover the heated metal as much as possible, to prevent excessive radiation, and to protect the welder from the high temperature.

*Consulting mechanical and electrical engineer, Pittsburg, Penn.

In some cases, where a high efficiency of the joint is expected, it is advisable to anneal the welded piece in a slow-cooling furnace for several hours.

It is well known, that in all rapid welding, such as electric, and to some extent autogenous welding, the joint is stronger than the section next to the joint on either side.

This can be explained by the fact that a molecular distortion takes place between the hot and cold parts and these molecules have no time to readjust themselves before the metal commences to chill. By the pre-heating and annealing process the distorted molecules will find their proper place again and each will take its share of strain exerted by an external load.

Fig. 8 shows welding a dome in a cylinder, a flange at the bottom, and an outlet at the side; all for high pressures.

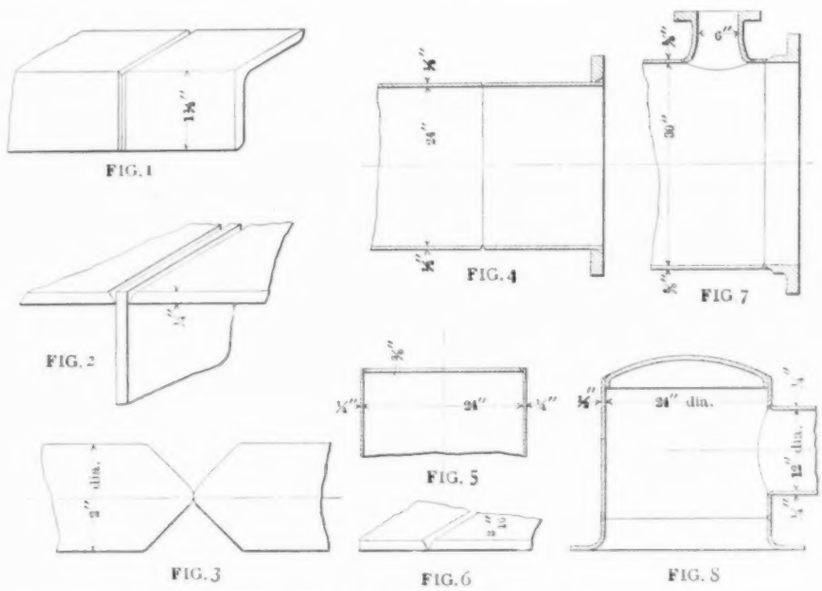
Conclusions

The process of autogenous welding is well adaptable in any metal work shop, and will pay good returns for the small first cost, and operating expenses.

The welding operation is not difficult, but requires several months of practice, to turn out reliable work for high pressure.

The process does not require any expensive machinery, such as power hammers and presses.

Over 1000 installations are in daily use in Europe, and bring good returns on the investment.



WORK READY FOR AUTOGENOUS WELDING

Experiments show, that with the same ultimate strength, the annealed piece will show a better elastic limit, and also a better ductility in the welded joint.

Fuel for Pre-heating

The pre-heating can be accomplished by natural gas or oil, or if power is cheap, by means of a resistance type electric furnace. The latter method is the most convenient, since it interferes least with the welding operation.

Fig. 1 shows the method of welding two angles together.

Fig. 2 shows a more complicated section, welding in a partition in a tank.

Fig. 3 shows the method of welding shafts, or any cylindrical sections.

Fig. 4 shows butt welding of large tubes, at the end of which a flange is welded on.

Fig. 5 shows welding of a top in a cylinder for light pressures.

Fig. 6 shows two plates ready for welding, with scarfed edges necessary from 1/8 inch up.

Fig. 7 shows a cylinder with a welded cast-steel nozzle, and a forged flange welded at the end.

We believe that in the next few years a new field will be open for the autogenous welding process, in boiler shops, automobile works, tank and plate works.

Aids to Information

The following paragraph, from an address by Charles Wallace Hunt upon "The Engineer," is worthy of careful reading:

"Engineering theory and practice are rapidly extending with the general advancement of our economic interests, and the engineer, whether he be a young graduate or otherwise, who does not make use of the modern aids to information, among which are to be counted scientific societies and a personal association with his brethren, with the innumerable hints and suggestions which come from these, will soon be found struggling with what seems to him adverse fate, but what, in reality, is inferior knowledge, behind-hand knowledge, or, plainly speaking, ignorance, greater or less. The engineering world has passed by him, and he must view the working out of the law of the survival of the fittest with what grace he may."

Some Interesting Antique Machine Tools

Modern Features Found in an Engine Lathe Seventy-four Years Old. The Difficulty of Departing from Existing Standards.

BY E. A. DIXIE

The American type of lathe with its raised V's seems to be the result of inventive genius rather than imitative ability or evolution from the European type with its flat bed. During a recent trip through New England I found the two lathes which I propose to describe in this article.

The one shown in Figs. 1, 2 and 3 was built 74 years ago by Baxter D. Whitney, now 90 years old but still young and hearty enough to come down to the shop almost every day.

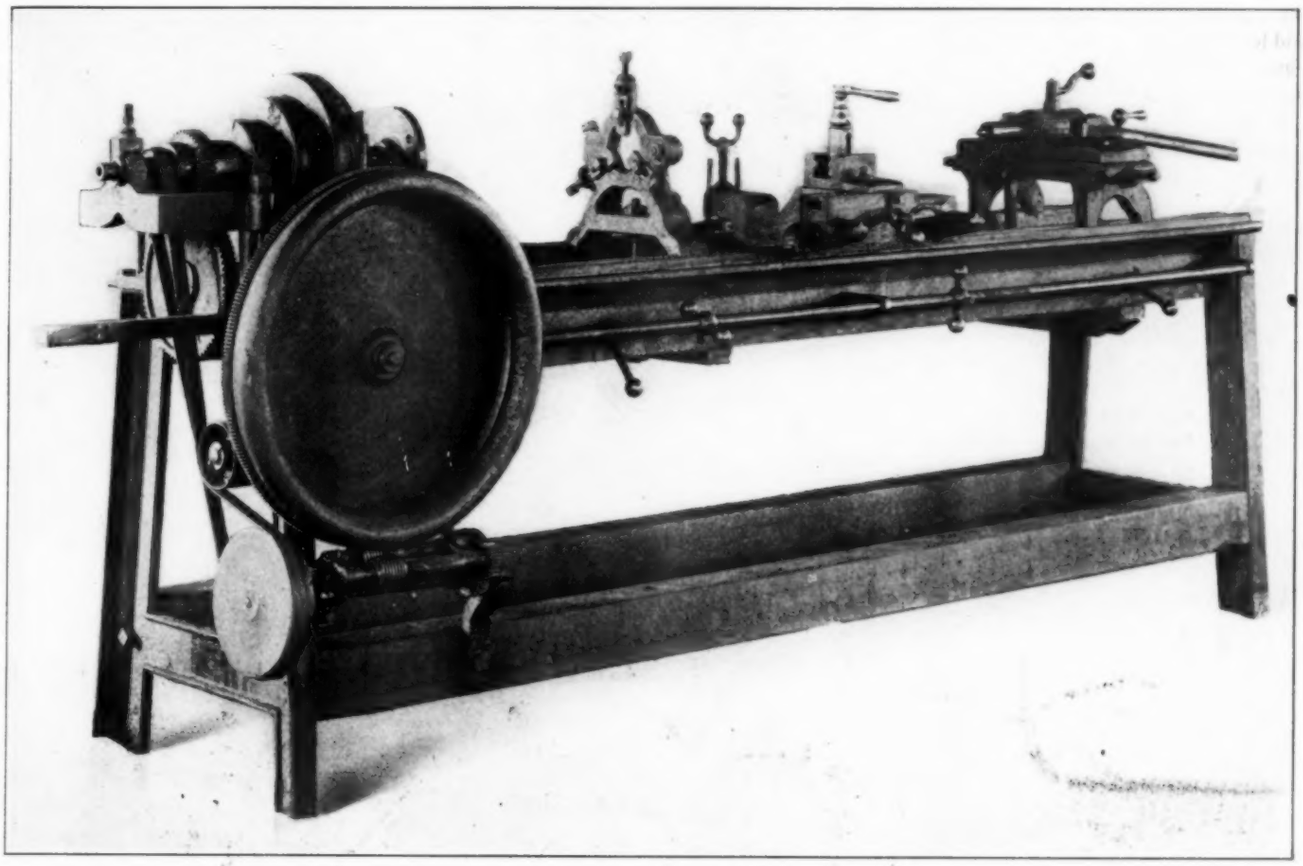


FIG. 1. FRONT VIEW OF THE OLD LATHE

As you read the following article you will recognize several *modern* features about this old lathe.

Baxter D. Whitney, born in 1817, acquired the trade of all-round mechanic in the repair shop of his father's mill where he played as a child in petticoats. At the early age of 13 he was a good enough mechanic to be sent to Worcester, Mass., to help build some looms which were being constructed for his father. He was 16 when he designed and made patterns for the lathe shown in Figs. 1, 2 and 3.

It is of the weighted type and swings 18 inches by about 6 feet. The bed, heads, carriage, steady rest and legs are of iron, but the two beams running lengthwise from leg to leg are of wood. The castings were obtained from a foundry in Worcester and hauled to Winchendon on a wagon. At that time (1833) there was no planer in Winchendon long enough to plane the bed. Chipping and filing were commonly resorted to in similar cases at that time, but this method did not appeal to young Whitney.

He laid the bed on the floor with a heavy beam of wood on each side of it. These were planed up true and lined up with each other and the bed. A traveling carriage was then fitted to the wooden beams and on this was mounted a milling spindle carrying cutters to finish the V's, the casting in between the V's being left rough.

The carriage of the lathe at the front rides on a round-topped V, and at the back a shoe travels on the flat top of the V, or more properly *rib*, which runs from end to end of the top of the bed. The shoe is provided with two pins which slide in holes in the carriage, as shown in Figs. 1 and 2. The elevating screw at the back of the carriage impinges on the top of the shoe. The idea of rounding the top of the front V was so that the rounded groove in the under side of the front of the carriage would find a seat with the back of the carriage elevated or depressed. The carriage is fastened to one end of a rack. The other end of the rack is shown in Fig. 1, projecting beyond the back of the feed wheel at the front of the lathe at the headstock end.

The tailstock, steady rest and headstock rest on the inner V's, the tops of which are flat. The back gear is under the headstock, as shown. Many makers of lathes at a much later date adopted this position for the back gear.

The feed works are driven from a two-step cone at the rear end of the live spindle by a belt to a two-step cone on a shaft running in brackets secured to the leg and wooden bar in front of the lathe. The belt passes under an idler which at first glance might be taken for a belt tightener. This is not the object of the idler, it being merely to prevent the belt from fouling the feed rack shown in Fig. 1.

The feed mechanism is best shown in Fig. 3. The lower spur wheel of the group shown in Fig. 3 is on the shaft to which the feed cone is attached. The other two spur gears mesh with it and are mounted on shafts which run in bearings in a pair of swinging yokes pivoted on the feed cone shaft. The other ends of these shafts carry respectively a right- and left-hand worm. The yoke nearest the observer is provided with a tail or lever having a slot in it.

In front of the bed and running from end to end of it are two rods. The one nearest to the bed is provided with single-ended ball levers. This shaft, in line with the slotted lever on the yoke, has a long lever which engages the slot in the lever by means of a pin which is free to slide in the slot. By rocking the long shaft by means of either of the single-ended ball levers, seen in front of the bed in Fig. 1, the right- or left-hand worm can be rocked into engagement with the teeth cut on the V-shaped edge of the large feed wheel; or with the worms in mid-position

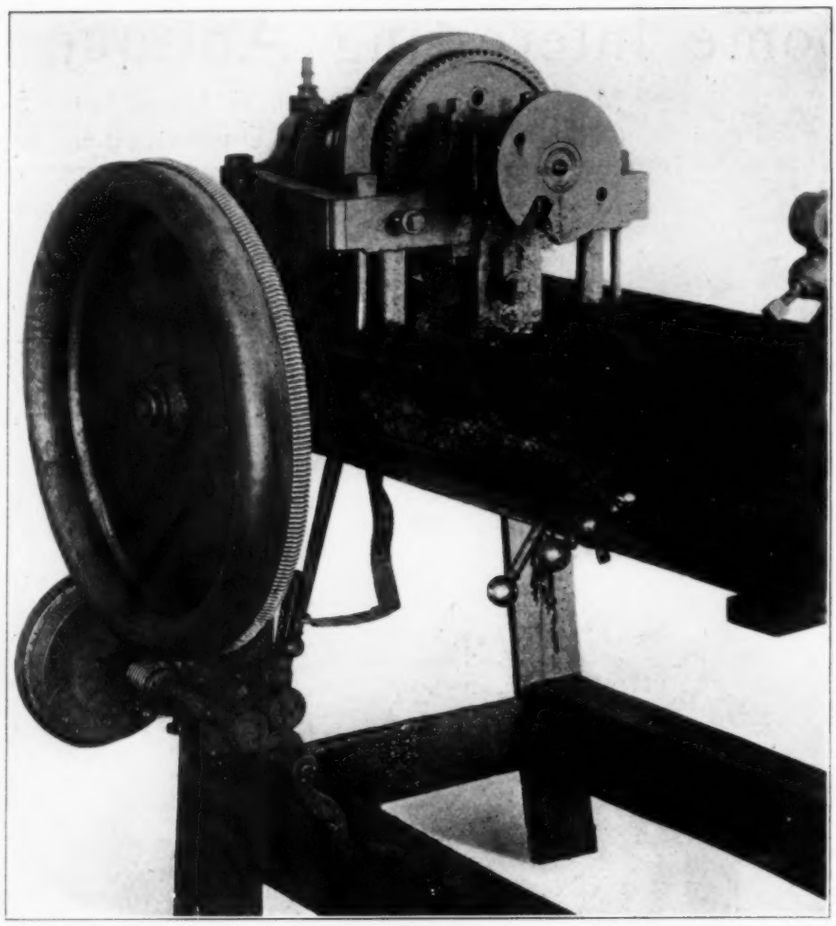


FIG. 3. THE FEED MECHANISM

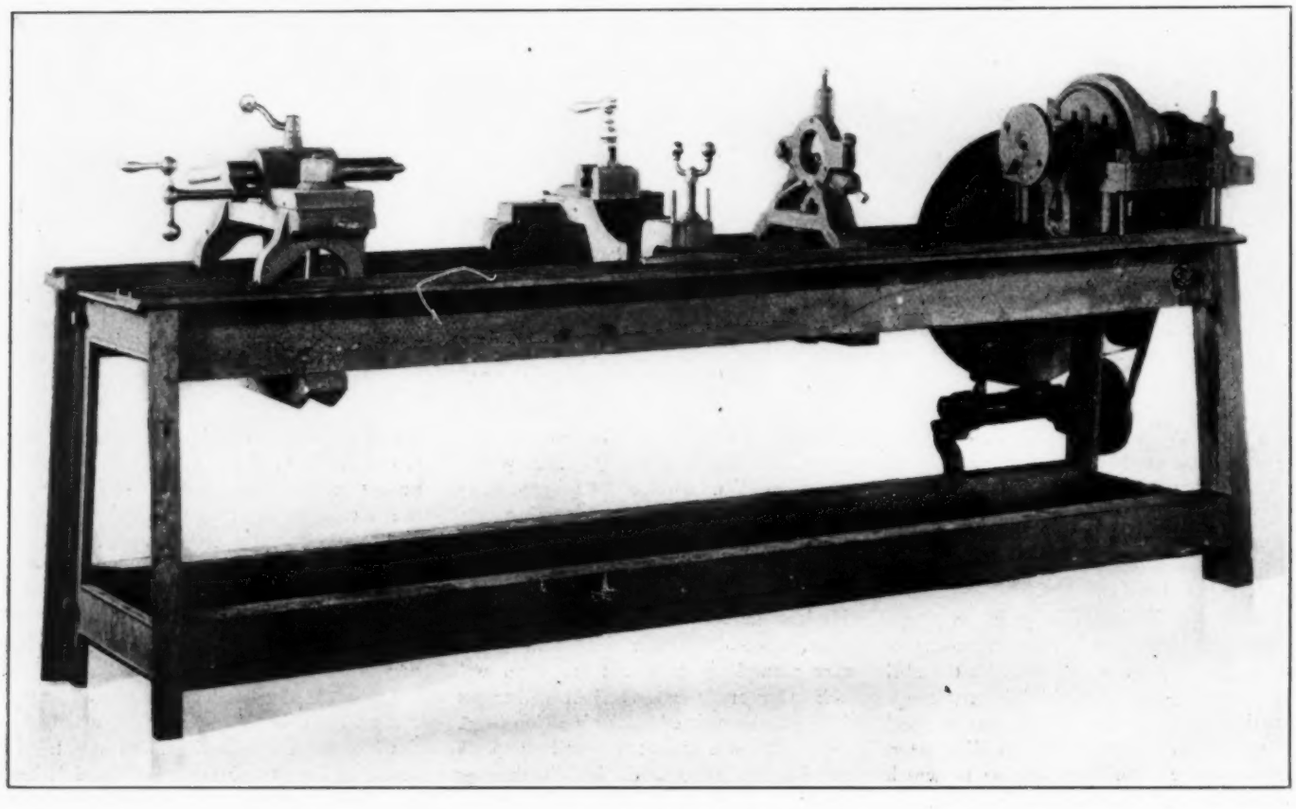


FIG. 2. REAR VIEW OF THE OLD LATHE

the feed wheel can be turned by hand, as neither of the worms is then in engagement. A hook shaped flat spring keeps the lever from shifting. The movement of the feed wheel is transmitted to the rack attached to the carriage, through a pinion on the shaft on which the feed wheel is mounted. Thus we have a stop or change of feed direction which can be operated from any point along the bed.

At the back of the feed wheel, and showing indistinctly at the junction of the bed and the front of the headstock, in Fig. 2, is a bevel gear. This bevel gear meshes with a bevel pinion mounted on the end of the shaft, provided with double ball levers, which runs along the front of the bed. When the worm gears are out of engagement with the feed wheel, it can be operated by hand from any point along the bed by turning the longitudinal shaft by means of the double ball levers.

The steady rest is a modern-looking affair but is supposed to be as old as the rest of the tool. All the cone pulleys are of wood or shod with wood.

This lathe was in operation up to about 10 years ago. At that time quite a number of the older tools, including a chain planer, were scrapped, but the two lathes here shown were cleaned up, put on skids and taken over to the storehouse which is the building where the business was first started and where the old lathes were built.

The second lathe, shown in Fig. 4, swings 19 inches by 12 feet; it was built some years later, how many I was unable to ascertain with any degree of certainty.

In this lathe there appear several improvements. The long rack sticking out beyond the headstock has been dispensed with, and one has been placed in front under the V, as in most modern tools. The V in the front and flat track in the back, as in the older lathe, have been preserved; and, by the way, some high-grade modern tool-room lathes are built with a V in front and a flat track at the back, for the carriage. The back gears are underneath, as in the old lathe, but a lead screw and rod feed have been substituted for the rack feed of the old lathe.

The change-gear quadrant is of peculiar design. The slotted bar under the quadrant was used as a strut to prevent the quadrant from shifting after it was once set. The stud (for the stud gear) is mounted on a separate bracket as shown.

The same large feed wheel is preserved; but instead of being stationary at the headstock end of the bed, it is hung in an apron on the carriage. The periphery is grooved and has worm teeth cut in it. The splined feed rod is hung on swinging brackets at either end, so that when the long curved lever, shown in front of the apron, is raised, the worm drops clear of the worm wheel.

The nut for screw cutting is solid and can be seen to the right of the carriage. It is secured to the apron by two tap bolts when it is desired to cut threads. A tumbler gear at the driven end of the feed rod permits feeding in one direction, while a direct gear and pinion drive provide for feed in the other direction.

The authors of "The Metric Fallacy" lay great stress upon the difficulty of departing from existing standards. This lathe supplies two examples supporting the truth of this assertion.

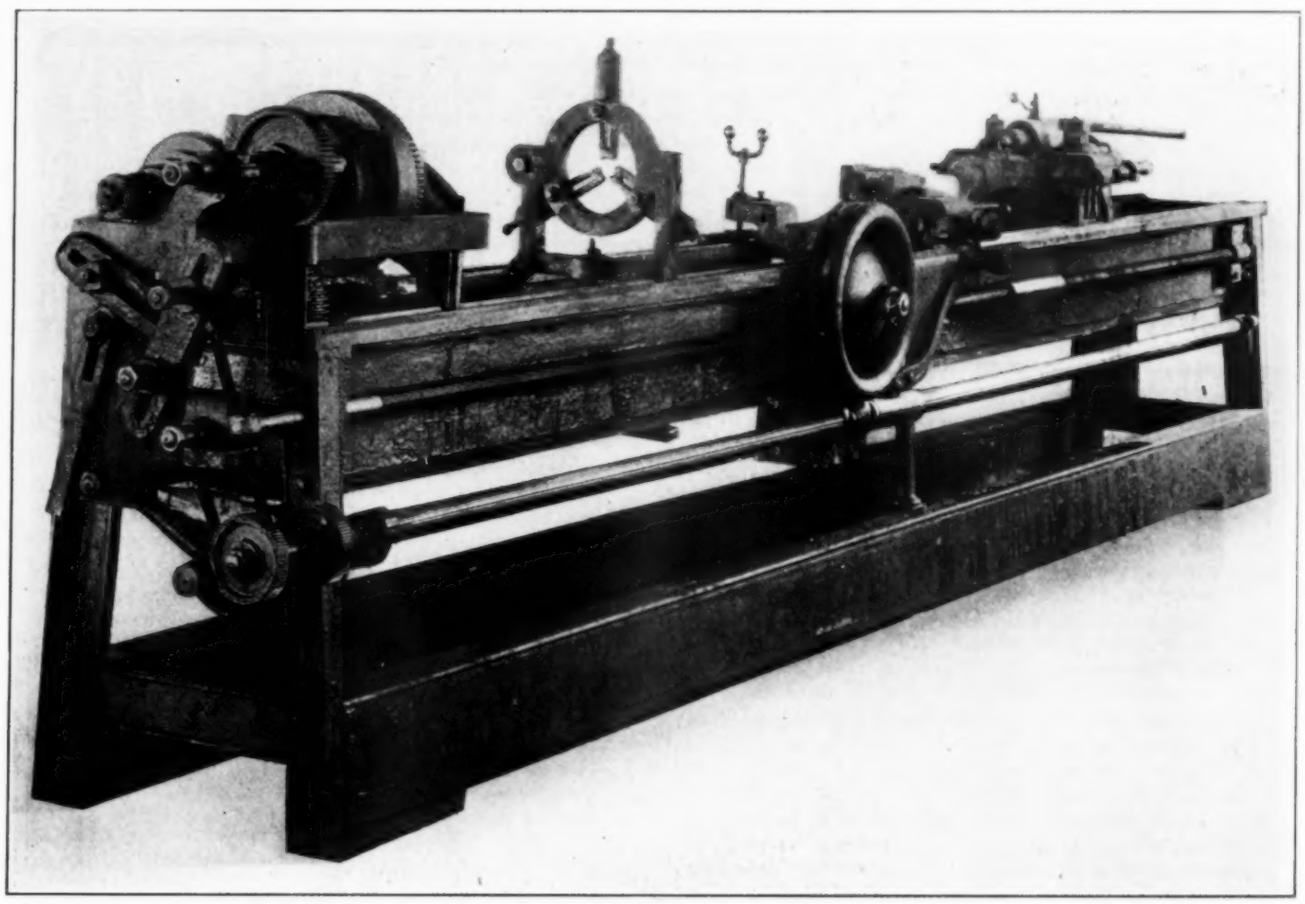


FIG. 4. THE SCREW-CUTTING LATHE

In the neighborhood of Winchendon previous to the building of this lathe was another one which had a bastard lead screw. Many threaded parts of machines used in the vicinity were cut on this, and of course as the parts wore out or were lost they had to be replaced. The lathe upon which the original parts were made was out of business; so Mr. Whitney had a screw-cutting table worked out for his lathe. This table shows 1483 different gear combinations, giving from 44/75 of a thread to 27 3/11 threads per inch. This table is shown in Fig. 5. It is stamped, by hand, on a sheet of copper. The copper plate was originally much larger, having a blank space on two sides

for further extensions; but they ran short of copper for liners one day, and the blank part was cut off.

Twenty odd years ago Mr. Sawyer, now foreman of the machine shop, went to work for Baxter D. Whitney & Son. He had charge of the tool room. Up to that time they had no plug and ring gages; but as will be seen later, they did have at least one standard. Mr. Sawyer decided that to facilitate the work a set of standard plug and ring gages was necessary.

The standard shaft size in the Whitney wood planer was 1 31/32 inches. When Mr. Sawyer asked where he could find a standard shaft to get this size from, he was referred to the large square nut on the front of the tailstock, shown in Fig. 4 with a wrench on it, and told to make the gage the same size as that nut, as that was the *gage* used by the shaft turners to set their calipers to.

On measuring it with the micrometer it was found to be 0.003 inch under size, but the plug and ring gages were made the same size as it, and to this day the standard gage for 1 31/32 inches in the Whitney shop is 0.003 under size.

The lathe was in its later days used principally for turning shafting; but some remarkable jobs have been done on it, notably the cutting of an increase pitch screw for a cloth-stretching machine. This screw is about 6 feet long and has a thread on it which starts at about 6 threads per inch and gradually increases to about 1 inch pitch. The nut used with it had, of course, only a portion of one thread.

Gas Flame to Replace Saw

By Robert Grimshaw

The employment of the oxyhydrogen blowpipe flame for industrial purposes is rapidly extending. Recently it has come into play for melting out "scaffolded" blast furnaces. It is further being used for melting off fins from castings, cutting off iron and steel, cutting out manholes—or cutting out the metal and leaving the holes, an' it please you better—and naturally, for welding. This latter operation has long been done with a blast flame consisting of hydrogen and ordinary air, where of course the oxygen being less plentiful, the heating effect is not so great. Among the welding processes thus carried out is the manufacture of wrought-iron tubes from strips of wrought iron wound about a mandrel. The Ferrum Iron Works, in Upper Schlesien, has extended the oxyhydrogen welding process to the manufacture of tubes, which being intended to withstand a very severe internal air, water or steam pressure without leaking, are made of quite heavy strips of iron or steel sheet; the latter by reason of their comparatively great thickness would not lend themselves very well to the spiral rolling process, hence are made with a lengthwise weld. The principal advantage of the gas weld is, independently of the greater speed and convenience in making it, the fact that no slag is formed between the welded surfaces, hence the seam is more truly "metal to metal." The Deutsche Oxhydric Gesellschaft has for some time been making experiments as to the shape of burner, etc., best adapted to do neat and rapid work in cutting off, or in cutting out metal plates, etc. The most recent development in this line is the combination of a foreheating apparatus employing oxygen and hydrogen, with a cutting jet of pure oxygen playing on the surface previously made red hot by this oxyhydrogen jet.

FIG. 5. THE INDEX PLATE FOR THE SCREW-CUTTING LATHE

Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

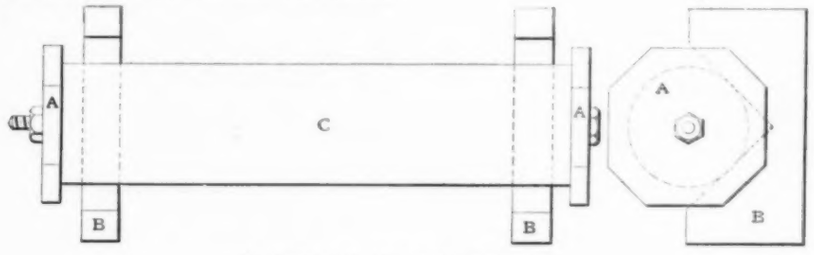
Making Air-hoist Cylinders—Liquid Chalking for Sheet-metal Work

I received an order to build several air hoists to be used in a large railroad shop, and was told to use what I could find around the shop to build them. I found some old 8-, 10- and 12-inch pipe. After cutting the pipe to the desired length, 6 feet, I was "up against" it to bore them out, not having a machine that I could use without going to a big expense to rig up special tools, so I tried the following way.

I cut two hardwood blocks *A* 12 inches square by 1½ inches thick, and bored a 1-inch hole in the center of each. I then got two old blocks *B* about 4 feet long and 10x10 inches, sawed a V in the center of each block and greased the V.

I filled the pipes *C* about half full of small pieces of scrap and sand and clamped the blocks *A* over each end by putting a rod through the center with a nut on each end.

I laid the pipe in the V-blocks and ran a belt around the pipe and over the line shaft so that the pipe made about 30 revolutions a minute. Allowing the pipe to revolve 10 hours, I examined the inside and found that all the high spots were worn down and that it was just as smooth and bright as if it had been machined. These hoists gave good service, and the packing



MAKING AN AIR-HOIST CYLINDER

leather will last a long time if kept soft by oiling.

To lay out work, mix whiting and water until it is about as thick as paint. Add sal ammoniac, 1 to 4 parts of water; this solution will not rust polished surfaces. After it dries thoroughly, it will not scale off and so is invaluable to sheet-metal workers. It can be applied with an old paint brush. If left standing in an open pail, the water soon evaporates and the whiting forms in a solid cake in the bottom of the pail; however, by adding water to it, it is just as good as when first mixed.

Hornell, N. Y. H. L. BURRHUS.

Boring Jigs without Laying Them Out

I have read with interest an article on page 497, on "Boring Jigs without Laying Them Out."

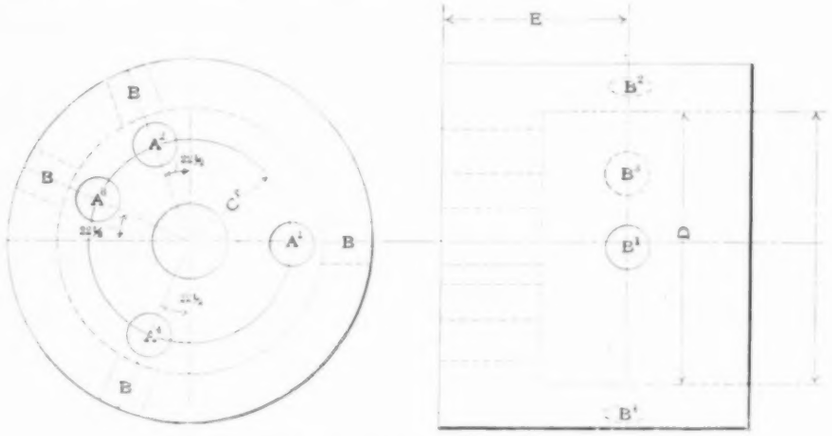
In the shop where I am employed we also bore our jigs without laying them out, although our equipment is somewhat different from that described in this article. Our milling machine is a regular universal, and of course the work must be set to be bored horizontally. This is not as convenient with flat jigs, nor is it so easy to see what you are doing on some work; but I think it is more convenient to operate the drill and boring bars on the horizontal machine.

Also instead of vernier attachments our machine has micrometer dials on all screws; this arrangement, while perhaps not quite so accurate as the verniers, we find to be accurate enough for nearly all work in our line.

I usually find that the holes in jigs are measured from some one or two planed surfaces. To get the center of the milling-machine spindle accurately in line with these surfaces for starting joints I use the following little "kink."

Before the work is put on the machine at all, put a piece of round stock in the chuck, fasten a lathe tool on the back part of the table and turn up the stock for a little distance so that it is perfectly round. Next remove the lathe tool, put on the work and square it up as desired.

Now take an accurate plug gage and run the work up near enough to the stock in the chuck so that the gage will just slide easily between the work and the turned-up stock. The whole diameter of the gage plus one-half the diameter of the stock in the chuck will be the distance the table must be moved to bring the center of the spindle in line with the end or the top of the work.


E
B
B
B

tionary during the entire revolution of the spindle.

The center of the spindle was then exactly in line with the center of the work. Now the dial or screw was set to zero and the table moved along a distance equal to radius C, and the hole A^1 bored.

The angle between A^1 and A^2 is 112½ degrees, which by a simple calculation is found to be 5/16 of a circle. We found also that the holes A^2 and A^4 could be located in sixteenths of a circle, so the head was set for sixteen divisions, the holes A^1, A^2, A^3 and A^4 bored in turn, and the head further revolved till hole A^1 was again in line with the center of the spindle. The head was set around parallel with the table to bore holes B.

The dimension E was taken from a true-running end mill of known diameter, which was set just to touch the end of the piece while running. The table was then moved along distance E plus one-half diameter of the end mill, which located hole B^1, which was then bored. Holes B^2, B^3, B^4 were located by sixteenths of a circle, as holes A, bored and the job was complete, with holes A and holes B in line with each other, which was the principal requirement of the job.

Charlestown, N. H. H. K. KRUM.

Die for Corrugating Copper Rings for Superheaters

This die was designed to automatically stamp copper rings for superheaters. Fig. 1 shows the die assembled and Fig. 2 the punch and the different parts which constitute the die.

A, Fig. 1, is a machinery-steel die holder. B is the lower die. C C, Fig. 2, are the slots into which four pieces C are set. The corrugated faces of B and C are cut together so as to match when in operation. D, Fig. 1, is the spring chuck which the lower die B is set into. E is the screw which holds the die B and the spring F in position. The work of the spring F is to force down the die B to its lower position. When the ram is on its downward stroke, the plate U (fastened to top plate T, which is fastened to the ram) as it goes down, strikes the latch N which rocks down, being pivoted in J. When U has gone down low enough the catch M rocks up again, being forced to do so by the spring O, and engages into the slot Y cut into U; see Fig. 2. As J is fastened to I and the latter screwed into B, when the ram goes up it lifts B to the hight of the chuck D which stands above C, as shown. The lifter I is allowed to lift B, traveling in the slots R cut out in the chuck D for that purpose. B on its upward movement strips off the work from the pieces C because B travels ⅛ inch more than C. After the ram has gone up a certain distance, the catch M gets out of slot Y, J being forced back by the pin L working in the diagonal slot K cut in A. The spring F forces the die B down to the bottom of the bore in A. As C is forced up ⅛ inch by the rubber pad H, B in its downward motion strips off the work from itself. The work remains loose on top of C, when it is easy to pick it off.

G, Fig. 2, is the bore in B for the spring F. Compressed between the head of the screw E and the bottom of the bore P is a screw which holds the chuck in its place. S are slots in the chuck to allow it to spring in and out.

D D are recesses in the chuck for the same purpose as the slots S. Q is the bore through the chuck D which the die B is slid into and on top of which die the copper ring is laid to be struck.

When the upper die W, Fig. 2, comes down on the work, it forces C against the bottom of the bore in A and then B and C stand to the same hight. V is the ring which closes up the chuck D as the machine comes down. V is bored out to allow the die W to pass through it and come against the bottom of the bore in the top plate T.

X is the screw which holds the die W on the plate T. The ring V is threaded on one end and screwed into the plate T and kept from moving by two screws Z Z, which have brass tips so as not injure the threads cut on V. Four other screws Z are screwed through the plate T and come against the bottom of ring V to compensate for wear or to strike thicker rings.

Ontario, Canada. G. A. BEAUDRY.

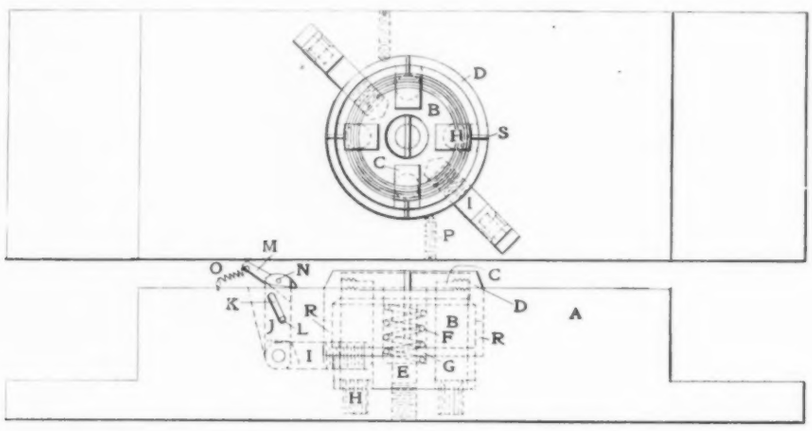


FIG. 1. THE ASSEMBLED DIE

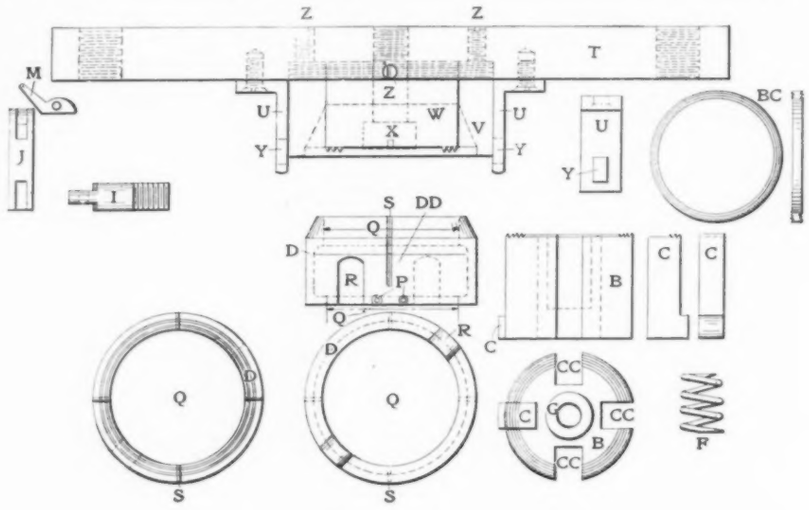
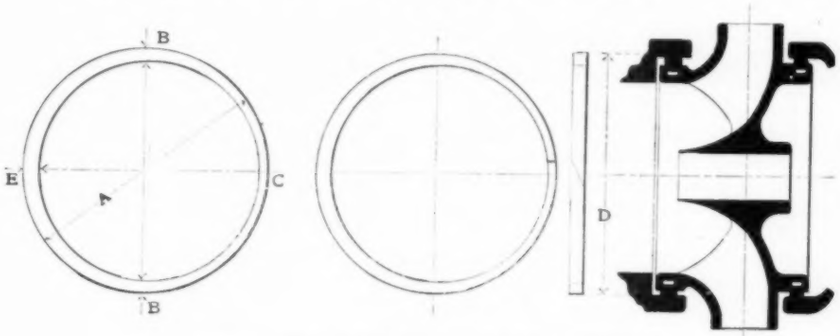


FIG. 2. THE PUNCH AND COMPONENT PARTS

A Split Ring for Centrifugal-pump Impellers

Engineers have long tried to perfect the centrifugal pump, and I wish to illustrate a simple method of reducing the leakage around the impellers. It is often necessary to allow as much as one-sixteenth of an inch clearance between the impeller and the pump casing, more especially in a pump having more than one impeller. This produces a loss in the quantity of the discharge, and this loss is increased as the diameter or the number of the impellers increases. This loss can nearly all be eliminated by using a spring ring, providing the ring is properly designed, as shown in the cut.

The clearance in this case can be as large as desired, as its space is entirely filled by the ring, which is made eccentric and then cut to fit the inside diameter of the flange on the casing, which should be machined smooth to allow for a tight fit. This ring is set in the impeller with very little clearance, thus closing the means of leakage. The diameter of the bore in the casing we will call D (see the illustration); the diameter of the ring before being cut should then be $A = D \times 1.0156$. The dimensions B, C and E should be $B = (D \times 0.0312) + 0.0937$, $C = 4/5$ B and $E = 6/5$ B. The width of the ring should be at least equal to B. These figures apply only to rings of cast iron I deem it advisable to use these rings wherever possible, as results of tests made with and without them show from 3 to 4½ per cent. in favor of the ring.



A SPLIT RING FOR CENTRIFUGAL PUMP IMPELLERS

Philadelphia, Penn. C. W. CLIFFORD.

Gas-engine Repairs

I am running a machine shop on a small scale and do considerable repair work; if some of the following ideas, or "kinks" as you may call them, are worth printing, you are at liberty to do so.

I have built several marine gasolene engines, and I think I have the bearing problem solved. The main trouble with hot and cutting bearings I have found to be that the machinist makes those bearings too tight, thereby leaving no room for the oil. In putting the bearing sleeve onto the crank-shaft, or *vice versa*, in putting the crank-shaft into the bearing, there should be a trifle play when the two are dry. Then when the oil is squirted into the bearing, the bearing will be perfectly tight and there will be enough room for the oil. I have found that a bearing constructed in this manner will never wear perceptibly or run hot. On the few small marine engines which I built about six years ago, there is absolutely no play in the bearings at the present time.

I have also found that it works to perfection not to use emery cloth on the crank-shaft bearing in the old way, but to move it back and forth while the crank-shaft is in the lathe, running slowly, about the same way as if you tried to drawfile the bearing. This will leave the marks of the emery cloth, which should be of a fine grade, spiral-like on the crank-shaft.

We have taken one of these crank-shafts in an engine that had run for a year, and upon examination found that the crank-shaft was exactly the same shape and size, and perfectly smooth. For the bearing we have used a phosphor-bronze sleeve.

I have also had the chance of reboring a number of cylinders which were ruined by the wrist pin in the piston working to one side and cutting a groove into the cylinder wall. Most manufacturers use a set-screw to hold the pin in place. This set-screw will sometimes work out and make things very unpleasant in the crank-case. In every instance where I have rebored, or fitted any piston, I have drilled a ¼-inch hole through the bearing and wrist pin, and also a hole 2 inches down through the wall of the piston. Then I have inserted a piece of round drill rod and bent it on one end. This will snap into place and stay there without any further trouble, and it can be removed at any time, if necessary, with a pair of pliers. See Fig. 1. Care must be taken that the pin does not quite come through the piston.

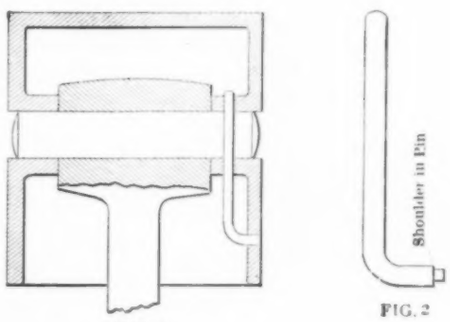


FIG. 1 FIG. 2 FIG. 3

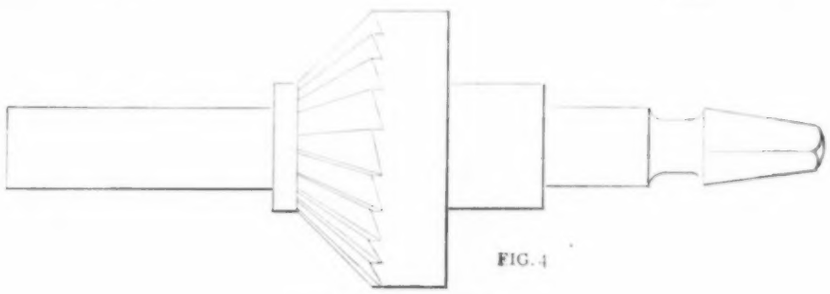


FIG. 4

SOME GAS-ENGINE REPAIRS

In keying a fly-wheel to a crank-shaft, I have found that in boring the fly-wheel smooth and the crank-shaft fairly smooth, the fly-wheel will what you might call "screw" onto the crank-shaft; it can easily be turned backward if necessary to remove it. The key in the fly-wheel should fit on the sides, top and bottom; but the key does not have to be driven in very tight, for a good fit on the shaft will keep the fly-wheel absolutely tight at all times. I think it is wrong to force the fly-wheel to the shaft in any other way, as in case the fly-wheel is to be taken off, the crank-shaft or the hub of the fly-wheel, or both, are as a rule damaged beyond repair.

In the construction of nearly all gasolene engines very little attention is paid to the oiling of the wrist pin and piston. As a rule they depend on what is called the splash system. I have found that in using enough oil in the base properly to oil the wrist pin in the piston in this way there is too much oil on the walls of the cylinder, which will burn and foul the spark plug and impair the power. By using less oil to get away from fouling the spark plug, the wrist pins in the piston seldom receive a proper amount of lubrication. In engines that I have built, or had a chance to rebuild, or fit a piston in the rebored cylinder, I have always fastened the wrist pin to the connecting-rod to let the pin work in the piston bearing, as in Fig. 3. This will give the wrist nearly as much again wearing surface as the old way, and the oil has a chance to get to the wrist pin. The wrist pin can be held in place to the connecting-rod by the same kind of a fastening as used in holding the wrist pin to the piston.

For recutting valve seats I have made a special tool, as in Fig. 4. The stem must fit the valve stem nicely; by putting a common brace to the upper part of the tool, you can get a perfect seat in less than a minute's time. For a different-sized valve stem you can make a different-sized stem for the tool. With this kind of a tool it will not be necessary to remove the head or the pockets.

Oshkosh, Wis. CHARLES KAUFMANN.

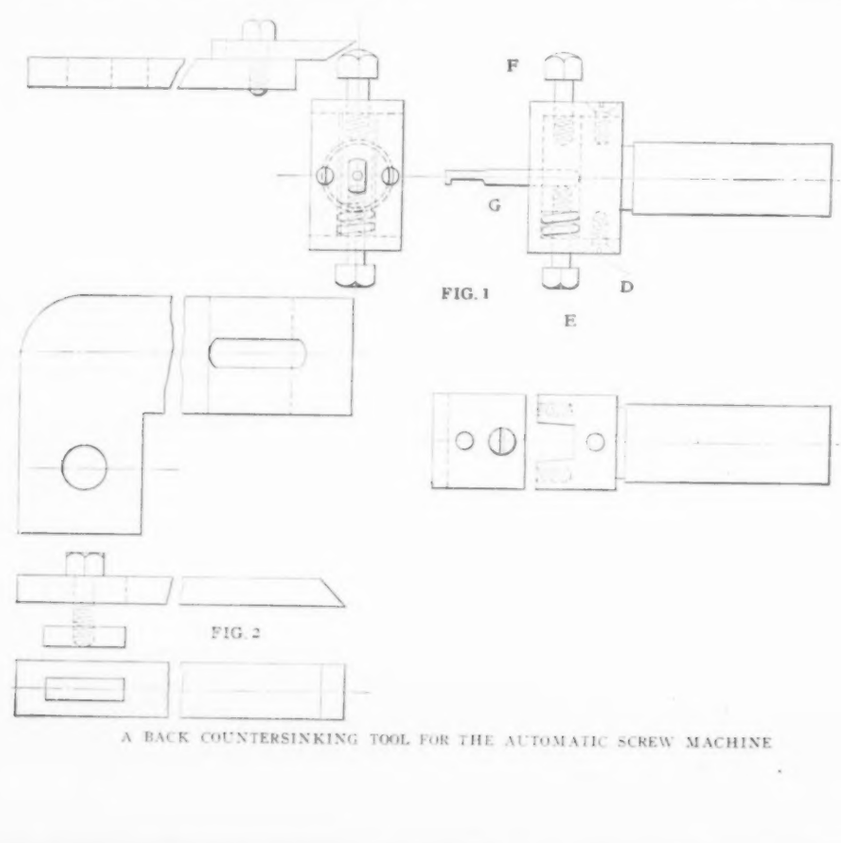
An Automatic Screw-machine Back-countersinking Tool

I notice on page 458 an illustration of a tool for countersinking the backs of nuts before they are cut from the bar. This tool may be all right for plain countersinking, but where a formed recess is desired it will be seen that the swinging movement of the tool makes it a difficult operation. To perform this operation as well as plain countersinking, I designed the tool shown in the cuts. It is very easily made and I find that it works well on Brown & Sharpe automatic screw machines.

As will be seen in Fig. 1, the tool is controlled by a depressor acting on the stud *F*, as used for unslotted nuts. The clamping screw *E* secures the tool *G* and also serves as a guide for the spiral spring *D* which returns the tool to its normal or central position after it has completed its operation. When the nut requires slotting it is necessary to cut off with the back cross slide and form and countersink with the front cross slide. In this case the countersinking tool holder is turned around with the stud *F* at the bottom and is controlled by the depressor, Fig. 2, which is screwed to the bolt slot of the front slide.

Mr. Chase prefers to countersink the nut before it is tapped. This involves a loss of time which is obviated by using a straight cutting tool, as the operation can be carried out while the nut is being severed from the stock without any injury to the thread. I have made a great quantity of nuts (down to No. 8, 0.086 inch diameter) in this way. They need no retapping and are ready for the assembling room when they leave the automatic.

Liverpool, England. T. ATHERTON.



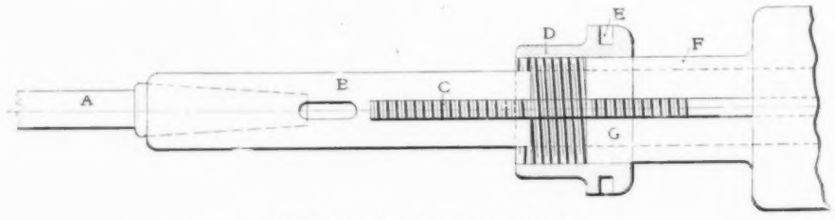
A BACK COUNTERSINKING TOOL FOR THE AUTOMATIC SCREW MACHINE

An Extensible Drill Spindle

The accompanying line cut shows an adjustable drill spindle designed to be used on a special horizontal boring machine. Referring to the illustration, *F* is the main spindle, held in a bearing having on its opposite end a gear or other means for driving. *B* is the adjustable drill spindle. *A* is the drill, *D* a spanner nut having a taper cut in its back end. The spindle *F* is threaded on the end, next to which is a taper *G* which corresponds to the taper in the nut *D*. This spindle is also slotted to receive the projecting threaded tongue *C* which extends through both sides of the spindle *B*, having a diameter equal to the threaded part of the spindle *F*, so that when it is placed in the slot it makes a continuous thread for the nut *D*.

It will be seen that the spindle *B* can be placed at any desired position and the nut *D* screwed in on the taper, causing the end of spindle *F* to be compressed on the spindle *B*, thereby giving it the effect of a chuck. The resistance of the threads in the tongue *C*, in addition to the friction of the compression caused by screwing up the nut, gives the drill a stable position at any point in its adjustment; the tongue *C* projecting outward in the slot furnishes a positive resistance to the drill.

Springfield, Ill. C. A. EDWARDS.



AN EXTENSIBLE DRILL SPINDLE

Bench Centers, Measuring with a Scale, etc.

The December 19 issue contains a number of things that seem to be of especial value and some that recall experiences of my own. The bench centers which Professor Sweet describes at page 949, Vol. 30, Part 2, reminded me of a pair that happened to occur in the first or second shop that I worked in, only that those had for a bed, if you could call it that, just a 1-inch steel bar to which the head and tail centers were attached. It had just the same sort of a scheme for holding the piece by spring centers, but all we could do about finding how near true the work ran was to try a piece of chalk. The method was to lean up hard against the bench and with the chalk between our hands, press them hard up against our stomachs; then by a sort of *hoochi-coochi* effect we moved the chalk up toward the work till it touched. Practice made it possible to get a chalk mark on almost every time before the piece lost its speed, but I would have thought a scheme like Professor Sweet's for finding whether it would clean up or not a great thing. But why doesn't Professor Sweet hang this thing on the front of a straightening press so that he can have everything handy? Then if he wants to get the cream of the real tony trade, he ought to put on an indicator that will read off the diameter on an enlarged scale. Then he ought to ask a fancy price for it.

I remember a shop where the foreman and I were all there was left in 1893, when

the panic swept the rest out. There was nothing else for us to do, so we were set to work to make a set of reamers. This was about as unprofitable a job as could be imagined for the shop; but we needed the tools and our pay seemed to be an expense that the proprietor felt like carrying, so we did not object. Well, we had nothing to measure with to get the sizes except a new 6-inch steel scale. It was a Brown & Sharpe scale, and we both knew that if there was any argument that all we would have to do would be to pass out the scale and tell the proprietor to measure the reamers himself. The boss was one of those old chaps of the kind that would spend six months laying out an index wheel if anyone would pay the bills (but that is another story), so he dug out a magnifying glass and he set all the caliper sizes on that job. He didn't have any hesitation about it, either; when he set a size he knew it was right; he did not know much about thousandths, but he knew that he was making the reamer just right. We ground these reamers on an old wooden-bed lathe that was once 18 inches; but by that time it had been raised to 30 inches, and we got just as nice a job as I have seen since.

But the point is here. Soon after this I got the "old man" to send out to Syracuse to inquire the price of one of Professor Sweet's measuring machines. You see I had been reading Chordal's "Letters" and I had some idea of a tool room. Pretty soon we got, not a quotation, but the machine itself. The very first thing I did was to measure up those reamers. Not one of them was more than 0.005 inch off size and most of them were within 0.002 inch. Mr. Alvord will please take notice of this, too, as corroborating his opinion as expressed at page 832. But the point is here, and it fits my present story. When we finally found the price of this measuring machine, the "old man" told me to box it up and ship it back. He said: "No man could afford to sell a machine that will be as accurate as you claim this to be for any such price. I want a hundred-dollar machine or nothing." And there you are. I have never done a job since at a cut rate that I did not think of this experience. If you can really do a thing well and quickly and you do it for a man that has money, it will be to your credit in his estimation for you to put a high value on your services. (N. B. I always wear my old clothes when I go to see the doctor.)

There is another objection to bolting a planer down beside the one that Mr. Norton gives on page 957, and that is that under the common law the planer then becomes a part of the real estate unless the bolts come up through the foundations so that the planer can be lifted off and leave the bolts in place. So if you are hiring a shop, don't use coach screws to fasten your machinery; use bolts up through, if you are afraid anybody will run off with the machines. I have built and run many lathes from 12 inches up, and I never thought of bolting them down no matter how accurately I wanted to test them. The bolt holes are to fasten the skids on with.

I wonder if C. H. Wells, page 958, will suggest a way of cutting a double thread with the tool rest set around at 30 degrees. I should think it would bother him to divide the lead exactly between the two pitches.

And I wonder if Mr. Sparks did not have unusually poor luck with this "wonder worker," page 959. He reminds me of a man that I saw once. He had five of these "wonder workers" in his shop, running on piece work and beating everything out of sight, when they were running; but they had a faculty, so he said, of breaking down every few days. I was not interested in these machines, as I had another of my own with its own crop of troubles on the other side of the room. By the time I had got acquainted with some of the men I told him that if he would change bosses that he would save himself a lot of repairs on my machine and the other, too. I do not know whether he took my hint or not, but that was the last repair job I ever had on mine. There is a lot of human nature in some men; some men can make anything work that they want to, and nothing will make anything else work. I believe myself, though, that if half the energy that is put into these "wonder workers" were spent in rigging up an engine lathe, it would make it compare pretty favorably.

Springfield, Mass. ENTROPY.

A Planing Jig

This jig was designed by the superintendent of the Landis Tool Company, Waynesboro, Penn., for planing long, thin plates used on their grinding machines.

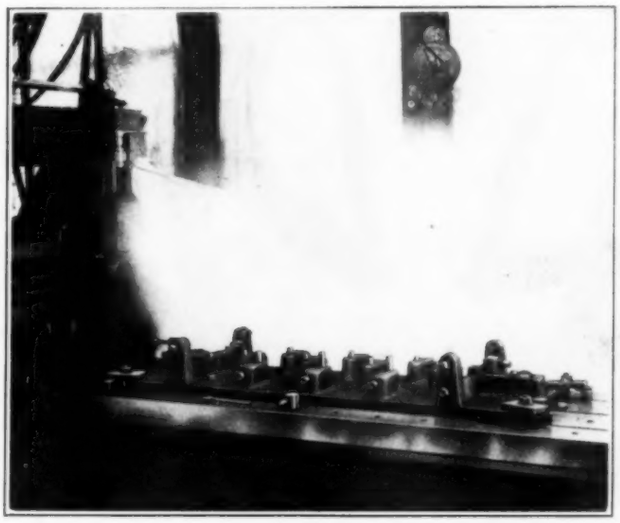


FIG. 1

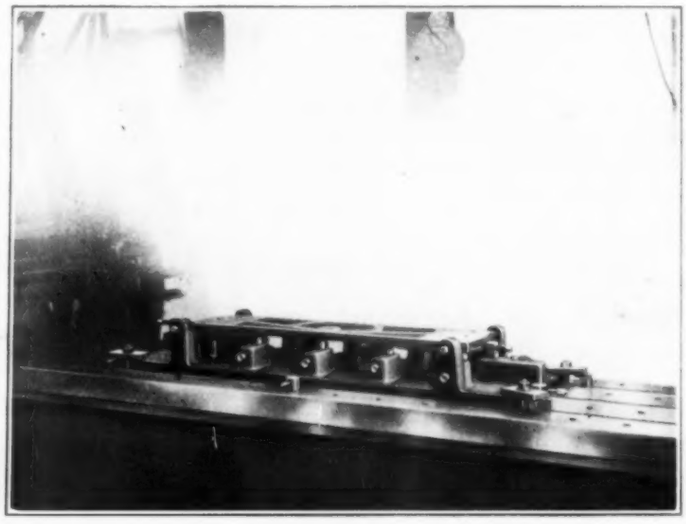


FIG. 2

A PLANING JIG

In the usual way of blocking up these plates, with set screws and jacks, it was often necessary to turn one several times before an accurate degree of parallelism and straightness could be obtained. This was due to the fact that it is impossible to determine closely the amount of swag at different points on the plate, and one screw might be adjusted so as to spring the plate a few thousandths too high while another might be as much too low; with the result that the plate would be sprung out of its natural position. If now a cut is taken when in this position, and the plate released and turned over on a flat, true surface, it springs back a little at the points where it was previously sprung and the surface just planed does not show true. By several turnings and careful adjustment it would eventually reach a true surface, but at considerable expense of time.

It was to eliminate this difficulty and save this unnecessary work that this jig was designed.

The illustration, Fig. 1, shows a plate, having a tongue on the bottom to fit the planer T-slot. It is provided with three rows of intermediate bosses, and three outer bosses; two of the outer ones are planed to provide seats for the planed surface of the table, and the third one provided with a set-screw coming against the rough surface, thus providing a three-point bearing to support the plate in leveling it up.

In each of the intermediate bosses is located a plunger, pressed upward against the plate by means of a spring. These springs are carefully adjusted so that when compressed the compression of each will be just equivalent to the weight of that portion of the plate which it is designed to support. Clamping screws are provided to clamp the pins in position. When the plate is put in the jig, as shown in Fig. 2, it is first supported on the three-point bearing, the plungers being held away until it is leveled up. They are then released one by one and press against the under side of the plate when they are clamped, each one thus taking its portion of the weight of the plate, and being clamped when in that position, so that it then forms a firm support for the plate without in any way distorting its position.

With this jig it is only necessary to turn the plate once, and the time of planing is much reduced.

Lancaster, Penn. H. F. Noyes.

Mandrels for Keyseating and Babbitting

In the accompanying illustrations, Fig. 1 shows a mandrel designed for quickly setting and holding on the planer the awkward casting shown in Fig. 2. In the bore of this casting it was necessary to plane four keyways 2⅜ inches wide by 1 3/16 inches deep, and two oil grooves, all 26 inches long. The casting is 42 inches long by 60 inches diameter across corners and bored 9 inches in diameter. The mandrel and extension bar in Fig. 1 are turned up about 45 degrees so as to show the construction more clearly. As can be seen, the mandrel is cored large enough to clear the 5-inch extension bar, and the longitudinal slot is wide enough to clear the keyseating tool. The two yokes hold the mandrel in proper alinement and a key in the front yoke keeps it from turning. The casting is turned on the mandrel for each keyway. Total time, for keyseating and grooving, including setting and changing, five hours.

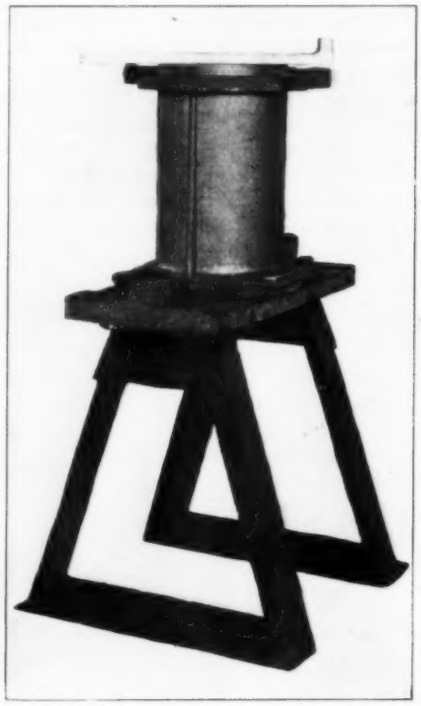


FIG. 3. COLLAPSING BABBITTING MANDREL

FIG. 4. USING BABBITTING MANDREL

Fig. 3 shows a collapsing babbitting mandrel and Fig. 4 the way it is used. The cope collar is made in halves and has two pouring gates. The taper key drives out through the slot in the base plate, allowing the mandrel to loosen up so that the journal box can be lifted off with ease. No messy clay is required, no trimming of rough edges, and a clean shipshape job is the result. Time for babbitting 10-inch box shown, 20 minutes.

Allentown, Penn. H. B. Robinson.

A Question in Engineering Ethics

In answer to Entropy's question "What do you say?" in his article on page 979, Vol. 30, Part 1, I say that the charge which he made was the right one. If I had been in his neighbor's place and some part of my engine had broken, while I would of course have been annoyed and worried, I would quickly realize that all I could do would be to have some machin-

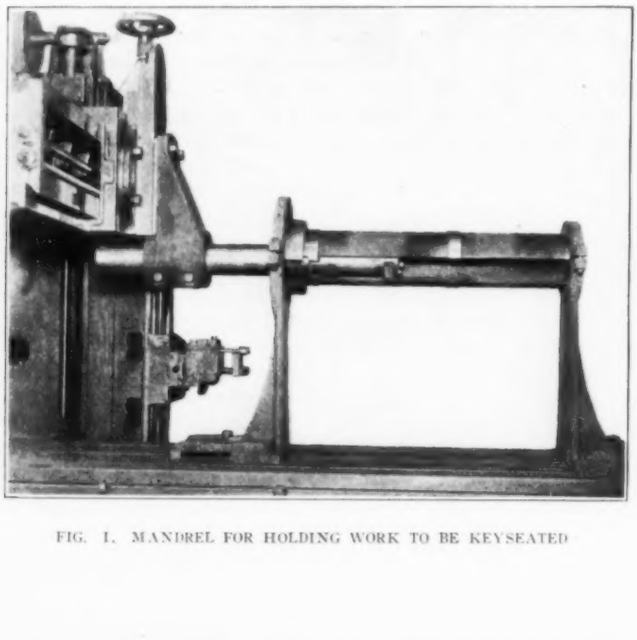


FIG. 1. MANDREL FOR HOLDING WORK TO BE KEYSEATED

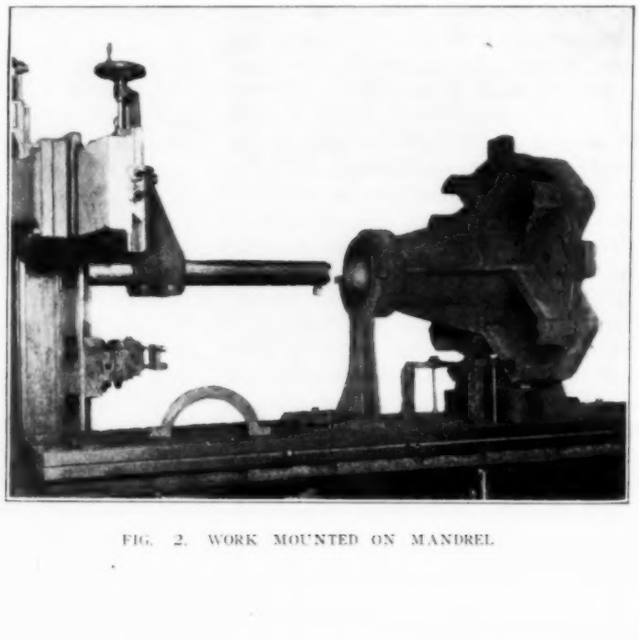


FIG. 2. WORK MOUNTED ON MANDREL

ist repair it, be charged for it, pay a bill and that would probably be the end of the incident.

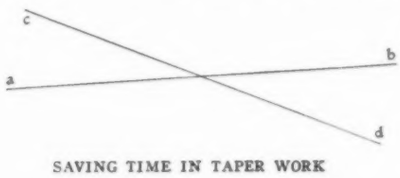
In the case as cited by Entropy, however, the fact that I could not start my engine and could find no apparent cause for its refusing to work would cause me mental worry and annoyance different from that in the case of a breakdown, and I would go to Entropy as to a friend to help me out of trouble. His doing so would call from me a sense of appreciation and obligation not to be measured by money, and one I would be apt to feel for some time. Now of course I think Entropy is entitled to some recompense for his services. The least I could do would be to offer him a fair rate per hour even if I did not feel like offering the whole of $50, the amount it would have cost me to get a man from New York. But putting myself in Entropy's place, I would feel that, not being out anything and having hardly exerted myself, I would gladly do the favor free, feeling that I was treating my neighbor as I would have him treat me. Who knows how soon my horse might have a little trouble that my neighbor could tell me in a few words how to cure, and thus save me the trouble and expense of sending for a vet? This service would probably be worth as much to me as my service was to him, but how much?

I think the world as a whole would be much better if more of us were more willing to lend a helping hand when it does not cost us any sacrifice, than to have to be paid for every little favor we do. Of course being called in in a professional way would be a different thing, but in the case cited I think Entropy did right in not making any charge but the ride home.

Waterbury, Conn. A. P.

Saving Time in Taper Work

Having had occasion at various times to bore taper holes to gage with the compound rest, I devised, some years ago, a method of operation whereby the element



SAVING TIME IN TAPER WORK

of chance as to just how far the gage would enter after the next cut was largely eliminated. Since it may be new to some of your readers, I give here a brief description of it.

Let the line *a b* represent the line of travel of the carriage, or a line parallel with the V's of the lathe, and the line *c d* that of the compound rest. Now we will suppose that the preliminary work has been done, the rest set to the proper angle and the hole bored nearly to size; bring the tool up until it touches the work, back it out of the hole by means of the compound rest, on line *c d*, move the carriage ahead on line *a b* as far as the gage still needs to go in and feed the tool through with the rest, which will complete the hole.

It is obvious that the same method will apply equally well on outside work and on several makes of lathes where the taper attachment is fastened to the carriage and only clamped to the bed when in use, as, for example, the Hendey-Norton. It will be found very convenient when boring or turning with the taper attachment, it being only necessary to loosen the clamp, move the carriage ahead as far as required and tighten it again without moving the cross slide.

Cleveland, Ohio. C. H. W.

Nurling Screw Threads

The job was a brass plug, as shown in the line cut, ⅝ inch diameter on the threaded end and about ¾ inch diameter on the cross-nurled part, this being done

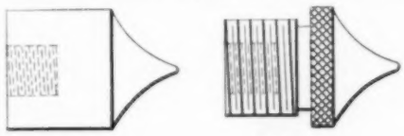


FIG. 1 FIG. 2

KNURLING SCREW THREADS

with a right- and left-hand nurl, as ordinarily.

The thread was 32 to the inch and had always been run down with a die until someone conceived the idea of nurling it. The old man, scenting a few seconds saved on the job, did not rest until he had seen the idea tried.

After some experimenting, it was found that the proper size of the nurl was 0.573. If made either larger or smaller, the thread would be crossed. The nurl was, of course left-hand, and made of ordinary tool steel, hardened and tempered as usual. The brass plugs were brought from the automatic screw machine, as in Fig. 1. A threaded plug was used in the spindle of the hand screw machine. With the lathe running forward, the blank was run on the stud and the outside turned down to shape by means of a formed circular tool. The threaded part was then nurled, and the lathe was reversed while the right- and left-hand nurls were brought up to form the cross-nurled portion. This loosened the piece enough so that it could be run off with the fingers while the machine was still running.

It may be of interest to note that the outside diameter of the nurl was very nearly the same as the diameter of the bottom of the thread on the plug (within about two thousandths). I do not remember ever having seen any rules for anything of this kind, and I for one would be glad to receive further information along that line.

Marquette, Mich. P. A. Fredericks.

Layout and Installation of Steam-pipe Lines—Erratum

In the article under this title which appeared at page 233, first column, sixth line from the top, it was stated that two feet of expansion could be counted on for all sizes of pipe for every hundred feet of length between a cold state and steam-heat temperature, whereas it should have read two inches of expansion.

An Improved Tool Holder

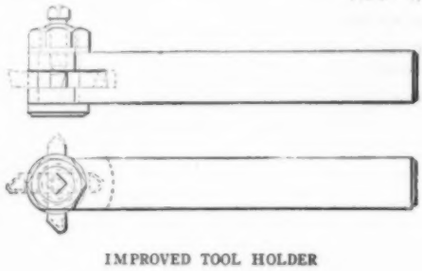
The tool holder shown consists of a mild steel body and clamping bolt with nut and a set screw.

The body is 1¼ inches square, having a head of 1½ inches diameter and slotted ⅜ inch wide by 2 inches deep with a reamed hole 1 inch in diameter.

The clamping bolt has a ⅜-inch square hole to receive the tools. Clearance should be made in the hole so that the tool will rest on the bottom surface of the ⅜-inch slot and not on the square in the clamping bolt; the tool can then be taken in and out freely.

The set screw is to secure the tool while the whole is being firmly clamped together ready for use.

The need of a satisfactory tool holder for work like automobile-crank turning is an absolute necessity if cost is considered. For crank turning a tool of heavy section and about 12 inches long is required to give rigidity and at least six of these tools of different shape are required for each lathe. With this tool holder the same work can be done



IMPROVED TOOL HOLDER

equally as well as with solid tools and in less time.

The tools are double ended, are 3 inches long by ⅜ inch square sections. It is easily seen that this would effect a considerable saving on the cost of tool steel. I have found that this tool holder is more adaptable than any other I have used. Its chief point is the central position of the tool and it has the advantage of a firm grip of the tool at any angle.

Coventry, England. A. E. Clark.

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None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

PAGE

Forming Tools for Automatic Screw Machines 299
Thread Miller Work..... 306
Two Speeds from a Constant-speed Drive 307
Two Methods of Making Master Cams.. 308
A Novel Ball Bearing..... 310
Individual Lighting for Machine Tools.. 310
Molding a Four-way Stand-pipe..... 312
Treatment of High-speed Steel..... 314
Some Applications of Autogenous Welding 316
Some Interesting Antique Machine Tools 317
Gas Flame to Replace Saw..... 320
Practical Letters from Our Readers:
Making Air-hoist Cylinders....Boring Jigs Without Laying Them Out....Die for Corrugating Copper Rings....Split Ring for Centrifugal Pump Impellers....Gas-engine Repairs....Automatic Screw-machine Back Countersinking Tool....Extensible Drill Spindle....Bench Centers....A Planing Jig....Mandrels for Keyseating and Babbitting....A Question in Engineering Ethics....Saving Time in Taper Work....Improved Tool Holder.....321-327
Two Uses of Precision Methods..... 328
Industrial Education at Indianapolis... 328
New Tools and Machine-shop Appliances 330

Two Uses of Precision Methods

During recent months we have devoted considerable space to the publication of toolroom methods of more than ordinary precision. The articles on the master plate, the accurate locating of holes in jigs, and the use of the microscope in the shop, are illustrations of the class to which we refer. These articles have been criticized as relating to work of an impracticable degree of refinement for commercial purposes, and the criticisms deserve a few words of discussion.

Methods of this kind have two distinct uses, one of which is lost sight of in the criticisms to which we refer. The first use is the very obvious one of doing work of the highest attainable degree of accuracy, while the second relates to the doing of work of a less degree of accuracy, the result of the method used being the easy accomplishment of results which, without it, could only be obtained with difficulty, if at all.

An excellent illustration of what we mean is found in the use of the precision level. Shop levels may be easily obtained today in which the graduations on the glass give readings as fine as a thousandth of an inch in two feet—even closer measurements being obtainable by estimation. Imagine a level of this character in use in the erection of a planer. Because the instrument used is extremely sensitive does it therefore follow that the adjustment of the planer must be continued until the bubble stands exactly in the center of the glass under every test that can be made? Obviously not. On the contrary, the instrument becomes an indicator of the degree of truth in the machine which may be set with any degree of accuracy required. It is not too much to say that a planer cannot be accurately set with the ordinary carpenters' level, which is too frequently used for that purpose. It is, of course, easy to set the planer with such an instrument so that it shall appear to be level, but the appearance is more apt to be deceptive than not and of the accuracy of the work, except between coarse limits, nothing is known, while the precision level permits any desired limit to be established.

The illustration is typical and applies to precision methods of all kinds. Many of the readers of this paper can recall the time when the micrometer was looked upon by many in precisely the same light, criticisms precisely parallel with those now made having been directed toward it. Today every one recognizes as a matter of course that while the micrometer is available for work of minute precision, its usefulness is by no means confined to work of that kind. It permits errors to be measured which previous methods did not, and precisely as in the case of the level it enables one to know what he is doing and to do easily what before was done with difficulty.

It would be easy enough to add to these illustrations, but we believe that to be unnecessary. The same principle applies to nearly if not all the precision methods which we have recently published. It seems indeed a little odd that the case should not be recognized at once and that it should be necessary to point out the distinctions we have made. The micrometer caliper is constantly before us as an illustration of the usefulness of high-class methods in work of an ordinary grade, and it would seem that its lesson should have been long since learned.

Industrial Education at Indianapolis

Now that such impetus has been given to the movement for trade schools by the Chicago convention, a few words regarding what has been done by the Winona Technical Institute at Indianapolis is eminently appropriate.

The Winona institute is the outgrowth of the Winona Assembly at Winona lake, which is closely parallel in its activities with the older institution at Chatauqua lake, the trade school, however, being a new departure. A great opportunity for establishing a trade school at Indianapolis came about through the abandonment by the Federal Government of an arsenal which had been established there many years ago. This arsenal occupied a splendid tract of land of 75 acres in extent and included some very substantial buildings which have proven excellently adapted to the purposes of the trade school, while the extent of the property offers unlimited opportunity for growth. The value of the land and buildings was appraised at $175,000 and it was offered by the Government at this figure, with the stipulation that the property should be used for educational purposes. Of this amount $140,000 was raised by subscription among the citizens of Indianapolis, the remainder of the required sum coming from the Winona Assembly.

In establishing the schools the support of the various employers' associations was sought and obtained, this support taking the form of contributions in cash for establishing scholarships and of contributions of equipment for the various departments, although many contributions have also been received from others not affiliated with these organizations. An advisory board has also been formed of representatives of the employers' organizations.

The institution is now in its third year and has already a goodly number of departments in operation. Among these are schools of printing, lithography, foundry work, house painting and decorating, electrical wiring, carpentry, tile setting, etc., while a school of machine-shop work is about to be established. This last has come about through coöperation

with the National Metal Trades Association and especially through the efforts of William Lodge as chairman of the committee of that association. Equipment to the value of about $30,000 has been contributed and a scholarship fund of $15,000 has been raised.

The Institution is not a free school, the charge for tuition being $100 per annum. Some of the courses, however, do not cover an entire year and in such courses the tuition is less than the amount stated. The scholarships are intended to meet this charge for tuition. They are not in any sense endowed scholarships, the amount contributed forming a loan fund which is loaned the students with the expectation that it will be returned after they have entered productive life. Just what form of security will be required for this return has not yet been determined, although, no doubt, some adequate security will be found necessary. In this, as in many other things, the authorities have simply gotten to work and left the working out of details to the future. In addition to the scholarships means for at least partial self support are offered in those departments in which it is feasible, this feasibility depending upon the opportunity to sell the products. In some of the departments, such for example as printing and founding, the work done is, so far as possible, commercial, while in such departments as tile setting and house decorating the work is necessarily of the exercise type, being done by the student only to be taken down and done again by his successor. The school of machine-shop work which is expected to open next spring will do commercial work as far as it is feasible.

The students in attendance now number about 400 and may be divided into two classes. While the fundamental idea of the school is to give boys the opportunity to learn a trade, an active demand has been found in some departments for instruction by those of mature years. In a considerable number of cases men in active life who have been so situated as to be able to acquire only a limited knowledge of their trades have suspended work and attended the school in order to perfect themselves in those branches in which their shop environment gave them no opportunity. In a few of the departments the proportion of these advanced students is as large as one half of the total, while in others it does not appear at all. There is a large possibility that the school may eventually develop in this direction, especially in view of the fact that it is not a free school. To what extent boys will live away from home and pay good money in addition in order to learn a trade is of course uncertain, although there can be no doubt that there are enough boys willing and able to do this to support some large schools. If suitable instruction of advanced character is provided there does not seem to be any doubt that large numbers of men of mature years who have not had suitable opportunities and who have come to realize the need and advantage of a better knowledge of their trades will avail themselves of such opportunities. While less is heard about schools intended to provide instruction for such men, than of those intended for boys, they are entitled to just as much and perhaps even more support. Certainly the men of mature years who have failed to find needed opportunities are entitled to just as much sympathy and opportunity as boys in similar circumstances.

Some things about the school are open to criticism and among these is its name. The term technical institute or its equivalent, institute of technology, has come to be associated with schools of engineering. A school which is intended to teach trades should announce the fact in its name and the name Winona Trade School or even Indianapolis Trade School would seem to be more appropriate than the present one. There is a constant tendency among educators to seek to exalt their office by offering instruction of a supposed higher grade as time goes on. The movement for industrial education should be held down to its fundamental purpose. The present name of this institution offers encouragement to the educational tendency noted and it has already been yielded to to a certain extent. Thus departments of instruction in pharmacy and in library work have been installed, while the catalog places the school of electrical work as a branch of a department of electrical engineering.

This latter department does not in fact exist in any true sense, but its inclusion in the catalog indicates a tendency toward a weakening of the school by dividing its purpose as does the appearance of the implied intention to do work in mechanical and civil engineering. The aim of the authorities is of the best and such departments as they have opened have been in response to a real demand. If, however, the demand is to be taken as a guide, there is no limit to the diversity of subjects which may be taken up and to the consequent weakening of the school by diverting its funds from its proper field. Instruction in engineering and in other branches of technology and applied science is already well provided for in this country. The active demand today is for instruction in the trades and we believe that this institution, together with others whose fundamental purpose is to give trade instruction should hold themselves rigidly to it. The field and the opportunity are large enough to satisfy the most ambitious educator and it cannot, in fact, be adequately filled for a generation to come. We believe in single-purpose schools.

These remarks are not intended so much as a criticism of this school as they are of a tendency among educators, as this is by means the only instance in the country in which the idea of doing any useful educational work tends to supplant the idea of doing one kind of educational work and of pushing it to the highest possible perfection.

J. K. Bougher

J. K. Bougher, president of the J. W. Paxson Company, Philadelphia, Penn., died February 12, having passed his 68th year.

Mr. Bougher was a self-made man, and in his early years became acquainted with J. W. Paxson, and together they formed the company of which he was president at the time of his death. In later life Mr. Bougher's business interests extended so that he was prominently connected with many industrial ventures aside from his own company.

Personal

Robert McF. Doble has opened an office at 528 Majestic building, Denver, Colo., where he will conduct consulting and supervising engineering practice.

S. M. Chandler, who has been for some time with the Pittsburg Supply Company, has recently associated himself with the Pittsburg Valve and Fittings Company, Barberton, Ohio.

Alex H. Hamilton has recently become president of the M. H. Treadwell Company, Chicago, Ill. Mr. Hamilton was previously general manager of steel works of the corporation of Milliken Bros.

Arthur H. Hadley, formerly with the Wheelock-Lovejoy Company, has severed his connection with that house to take charge of the hardening department of the E. C. Bliss Manufacturing Company, of Providence, R. I.

Ellis C. Kent, on the engineering staff of Hugh L. Thompson, Waterbury, Conn., has established an office of his own at 120 Liberty street, New York City, where he will conduct a general mechanical engineering practice.

John Schuff, for some time connected with the International Harvester Company, looking after all kinds of automatic machine work, is soon to accept the position as superintendent of the Duer Manufacturing Company, Chilton, Wis.

Charles W. Aiken has relinquished his position of chief engineer with the Proctor & Gamble Company to become interested in the firm of Houchin-Aiken Company, Brooklyn. Mr. Aiken is to act as secretary and treasurer of his new company.

Charles E. Davis, who has been abroad for the past year, has become superintendent of the American Locomotive Automobile Company, Providence, R. I. Mr. Davis was at one time manager of the Pratt & Whitney Company at Chicago, and general superintendent of the Illinois Sewing Machine Company.

New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make It Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

New Universal Cutter Grinder

The illustration shows the latest development of the universal tool and cutter grinder of the Wood Engineering Company, Alliance, Ohio. It is, as the name implies, strictly universal in all its movements and will grind any milling cutter or reamer within its range accurately and quickly. As will be seen, the knee is supported by a central column and may be swung in any position around it. This is obtained by a spiral pinion and rack and the pinion shaft is set at an angle of 45 degrees, so as to bring the hand-wheel to the most convenient position for its operation. This throws the pinion near the center of the table and gives the greatest amount of table travel with the least overhang.

All table slides have 45-degree dovetails and are provided with adjustable gibs to take up wear, and have dust guards to keep the abrasive from wearing surfaces.

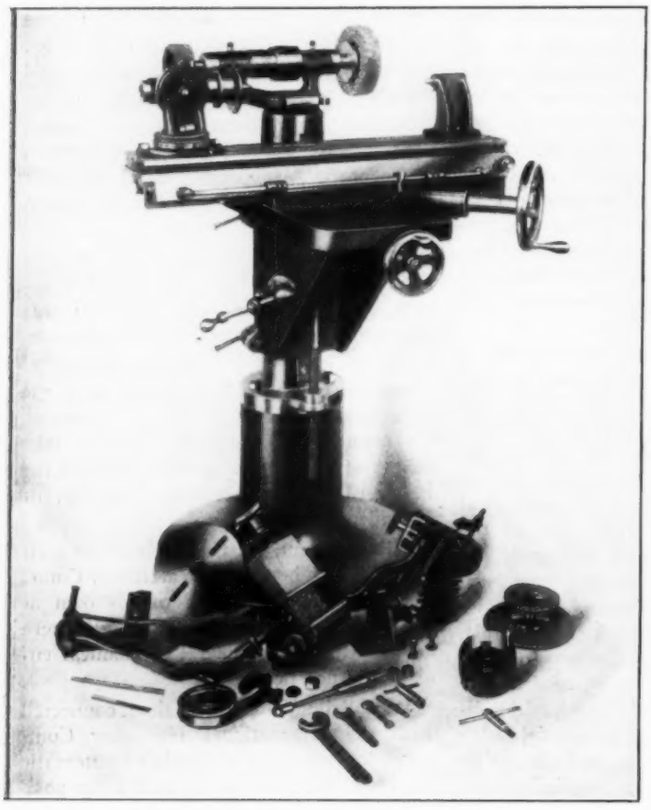


FIG. 1. NEW UNIVERSAL CUTTER AND TOOL GRINDER AND ATTACHMENTS

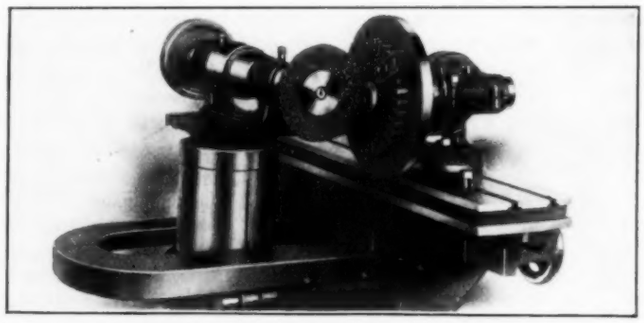


FIG. 2. GRINDER SIDE OF CUTTER

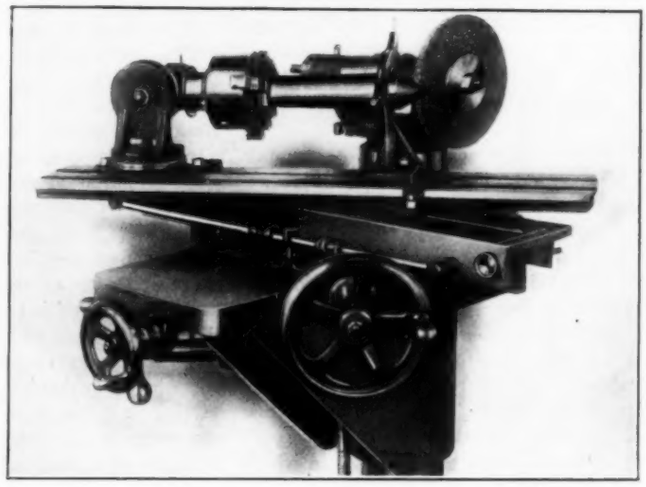


FIG. 3. SWIVELED FOR LARGE TAPER

allows it to be set at any angle with the grinding spindle and the top of the column is graduated in degrees. After the desired angle is obtained it can be locked in position by two 5/8-inch nuts. When the desired angle is secured the knee may be raised or lowered to any point in its travel without disturbing the reading previously obtained, and as both the elevating and cross-feed screws are provided with micrometer dials which read in 1/1000 of an inch it is easy to obtain accurate setting.

The longitudinal travel of the carriage is 18 inches. The table is in two parts, the top swiveling on a center pivot and having binding bolts at each end so that it can be swiveled for taper work either between centers or clamped to the table itself, two T-slots being provided for this purpose. The end of the table is graduated to read to 1/16 inch per foot. For grinding operations which require the upper table to be held at a greater angle than is provided for by the regular adjustment, two dogs are provided for clamping the two tables firmly together, as seen in Fig. 2.

The universal headstock is graduated in both directions, and has a hollow spindle which runs in dust-proof bronze bearing. The spindle has a 13/16-inch hole through it, and is provided with a No. 3 Morse or Brown & Sharpe taper, as preferred.

The emery-wheel spindle has two speeds, is made of tool steel, and runs in phosphor-bronze bearings, which are adjustable for wear. This gives two speeds for the internal-grinding attachment, which is so designed that the spindle has a bearing next to the emery wheel which prevents overhang and, consequently, much of the vibration.

The universal vise is very compact in spite of having three swivels so that it can be placed in any position. This in connection with the micrometer vertical adjustment makes the machine a very complete surface grinder within its capacity. There is also a combination V-block which fits the headstock and gives the horizontal and vertical swivel. This is very handy for grinding cutters held on taper shanks and which are too large to enter the hollow spindle.

The principal dimensions are: Longitudinal travel, 22 inches; cross travel, 7½ inches; vertical travel, 9 inches; distance between centers, 22 inches, and swing, 9 inches. Complete, without countershaft, it weighs 700 pounds.

The Simonds Screw Slotter

A recent development in blades for use in hack-saw frames, especially adapted to

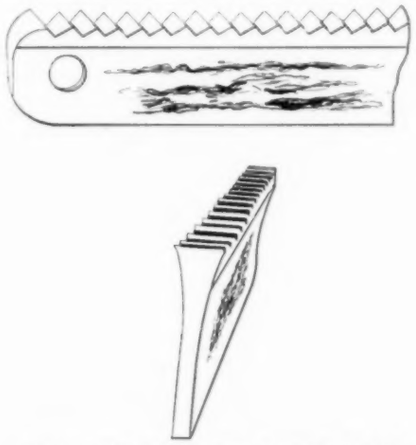


FIG. 1. SIMONDS SCREW SLOTTER BLADE

the cutting of slots and key-seats has been brought out by the Simonds File Company, Fitchburg, Mass. The feature of these blades is that they are concaved, being considerably thicker across the teeth than at the back. This feature is illustrated by Fig. 1. Four of these blades of different thicknesses form a set. They are all 8 inches in length and of the following thicknesses: 0.109x0.080, 0.083x

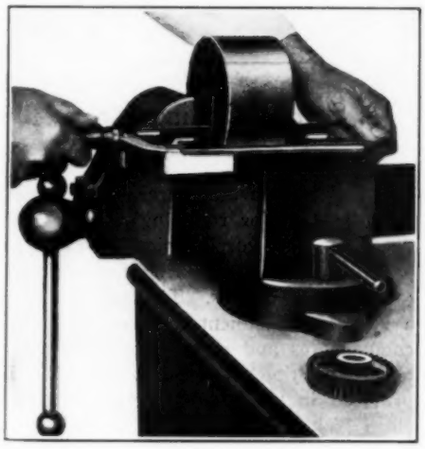
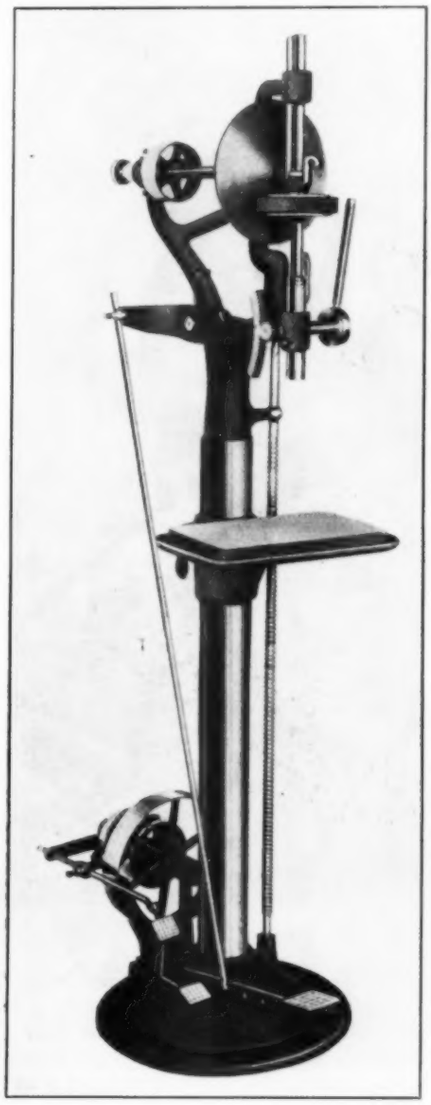


FIG. 2. TYPICAL APPLICATION OF THE SLOTTER BLADES

0.065, 0.065x0.052, 0.049x0.039. The material is highly tempered steel, and the teeth are accurately milled. They are intended to be used in ordinary 8-inch hack-saw frames and their field is the cutting of odd slots, such as slots in screw-heads and door keys, keyseats in pulleys and gears, special cases of die work and the like. The half-tone, Fig. 2, is representative of their use.

Sensitive Drill with Hand and Lever Feed

It often happens in sensitive drilling work that either hand- or foot-feed would be desirable, it being sometimes more convenient to use one and sometimes the other. So the W. F. & John Barnes Company, Rockford, Ill., have brought out the drill press shown herewith, the method of obtaining both feeds being clearly shown in the illustration. The



SENSITIVE DRILL WITH HAND AND FOOT FEED

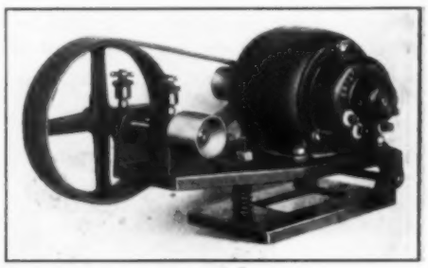
handle for the elevating screw is partially hidden behind the drill spindle and head. This is at present built in the 10-inch size and is being well received by stove manufacturers and those doing similar work.

Motor-countershaft Belt Tightener

A simple device for tightening the belt from a countershaft has recently been developed by the Crocker-Wheeler Company, Ampere, N. J., and is shown in the accompanying illustration. It is intended for motor-equipped countershafts and thus for general machinery use.

The device consists of a cast-iron base on which the motor and countershaft are mounted. The base is pivoted at one end of the sub-base, and belt tension is produced by means of a screw and adjustable nut at the other end. A spring is provided to support the movable base in case of the breaking of the belt.

The belt between the motor and

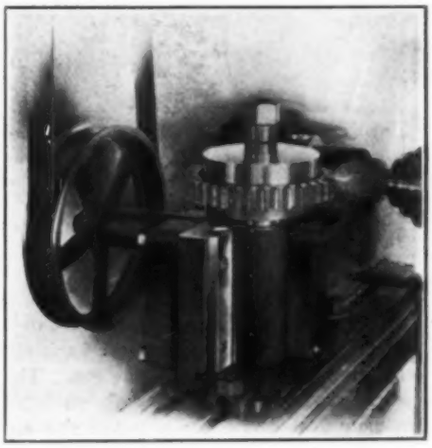


A MOTOR-COUNTERSHAFT BELT TIGHTENER

countershaft is tightened in the usual way, by shifting the motor on the movable base by the adjusting screw.

The "Long-arm" Automatic Tooth-chamfering Attachment

The milling-machine attachment shown by the accompanying illustration is designed to automatically chamfer, or round, the ends of gear teeth to a uniform contour and with a smoothly finished surface. Its principal field is for transmission gears of automobiles and the sliding gears in



THE "LONG-ARM" TOOTH CHAMFERING ATTACHMENT

machine-tool gear boxes. Its capacity is for gears from 2 to 9½ inches in pitch diameter, and from 4 to 10 diametral pitch. A special countershaft forms part of the complete attachment.

Referring to the half-tone, the attachment consists of a cast-iron base arranged to be bolted to the milling-machine table. This carries a work slide having a vertical movement and operated by a cam. The

vertical work spindle is carried by this work slide. This spindle is of hardened steel and is ⅞ inch in diameter at the portion to which the work is fitted. Bushings adapt it to the bore of any gear within its range.

The work-slide cam is on a cam spindle which carries a gear. This gear engages a pinion on the main pulley shaft and from which it derives its motion. There are two positions for the cam roll as there are two cam-roll studs set in the back of the work slide. The upper position is used when chamfering the upper ends of the teeth of the gear, and the other when working on the lower ends of the teeth.

The work is revolved by means of a worm carried on a shaft at the back and engaging with the teeth of the gear. This worm shaft is driven through an intermediate gear carried on a rocker arm and meshing with the cam-shaft gear and a pinion on the worm shaft. The position of this shaft is of course adjustable for different diameters of gears. As the worm meshes with the work there must be a worm for each pitch of the gears to be chamfered.

The cutters are adapted for a ½-inch straight shank milling-machine collet. By using cutters of different shapes, different contours may be given to the chamfer.

When run at a proper speed about 12 teeth can be chamfered per minute.

The attachment is built by the "Long-Arm System" Company, Cleveland, Ohio.

A Former Attachment for Lathes

This attachment is for producing formed work such as crowning pulleys. The design is such that in crowning pulleys only one former is required to produce different degrees of crown.

The attachment is secured by two bolts *a a* to the tool post slide of the lathe. The tool post *b* with its tool *c* is carried at the left of the carriage on a slide *d* which is movable to and from the axis of the lathe. To the slide *d* a roll *e* is secured which enters a formed slot *f* whereby it is engaged by the slide *g* in which the slot is formed. If the slide *g* remains stationary and the tool *c* travels as in turning the pulley *h*, the roll *e* will follow the slot *f* and impart to the tool *c* a movement corresponding to the form of the groove *f*. The path of travel of the tool may be modified by moving the slide *g* concurrently with the travel of the tool *c*.

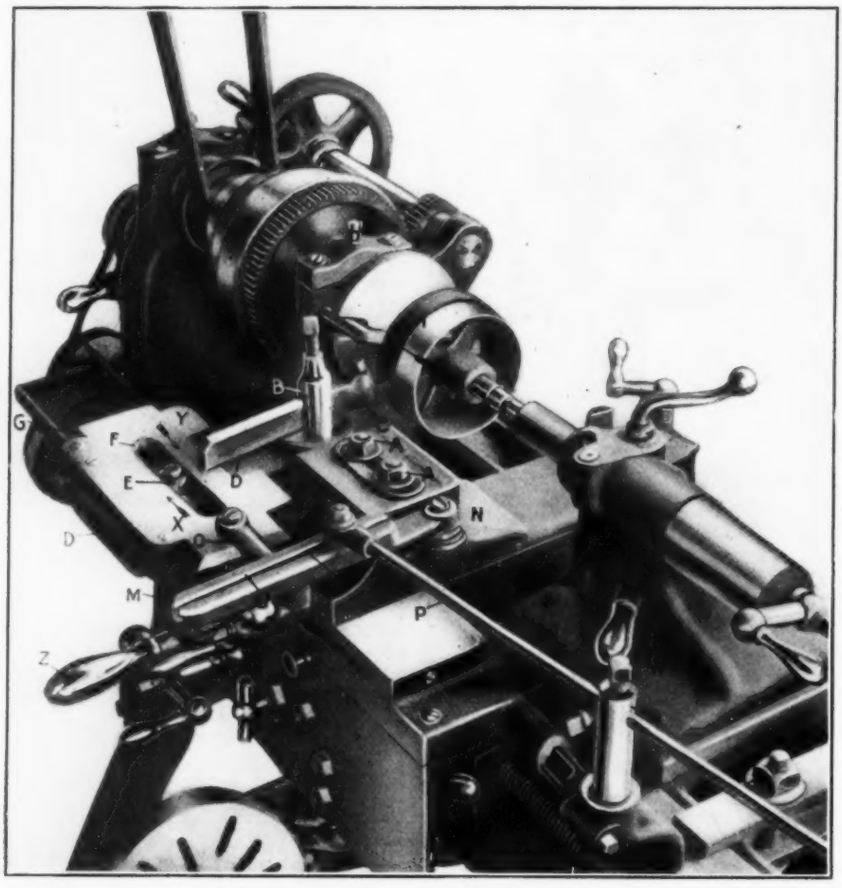
If the slide *g* be moved in the same direction as the tool *c* then the crown cut by the latter will be flatter, or of less curvature than when the slide *g* is stationary and the roll *e* simply follows the form *f*. If, on the other hand, the slide *g* moves in a direction opposite to that of the tool *c* then the latter will cut a crown that is ranker, or of greater curvature than when the slide *g* remains stationary. This difference in degree of crown is secured by means of the radius bar *m*, secured to the fixture at *n*, and connected with the slide *g* by the link *o*. It is also connected by a tie bar *p* with some stationary element as the bracket *r* secured to the ways of the lathe.

It is preferable to secure the bracket *r* to the tailstock, permanently, where it can usually remain when the attachment is not in use, without interference with other work. The radius bar *m* is T-slotted and in the slot is a slidable T-bolt *s* by which the tie bar *p* is connected. When the tie bar is secured, as shown in the photograph, by the T-bolt *s* which is the fulcrum of the radius bar, the lathe carriage and tool moving in the direction indicated by the arrow *x* will cause the slide *g* to move in the opposite direction indicated by the arrow *y*. This causes the tool to cut or turn an abrupt crown.

Were the tie bar secured at *t* just at the connecting point of the link *o*, then there would be no movement of the slide *g*, and the tool *c* would cut a crown, the counterpart of the formed slot *f*. Were the tie bar *p* secured to the radius bar *m* at *u* then the slide *g* would move *in the direction of the arrow* and cause the tool *c* to produce a crown flatter than the crown of the formed slot *f*.

With this device, special arbors are not necessary. The pulley to be crowned can be located anywhere on its arbor. On very abrupt curves the former is made to travel faster. In this way curves can be produced which could not be made with a stationary former.

This attachment is made by the Mossberg Wrench Company, Central Falls, Rhode Island.



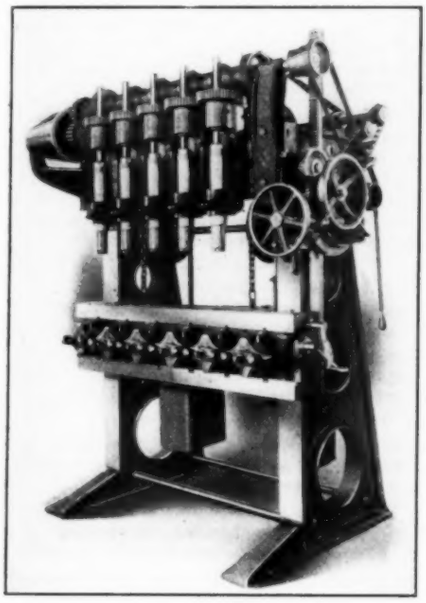
A FORMER ATTACHMENT FOR LATHES

A Special Drilling Machine

The special machine herewith illustrated was designed for roughing and finishing operations on cored holes in cast-iron parts; each hole requiring five different tools and operations. The spindles have a vertical adjustment to allow the drills, counterbores and reamers to be set in a proper position, while a screw collet is provided in the end of each spindle for close adjustment. The castings are clamped in the holders and the work table is fed up to the spindles. Its motion is from a three-step feed cone through a worm and gears into two racks, one on each side of the machine. An adjustable stop controls the feed and after the operation is completed the work table is returned to its first position by a quick movement given by two friction pulleys on a bevel-gear shaft with open and cross belts; operated by the lever showing on the side of the machine. This gives a quick movement to the work table in both directions and there is also a hand adjust-

ment by the wheel on the side of the machine.

The work holders are moved across the table by a crank to a stop pin at the end. This brings each piece of work directly in line with its revolving spindle. A slight movement of the handle below the crank binds the work holders during the operation. At each operation the end piece at the left of the machine is finished. While the next one is in process the operator replaces the finished piece of work with an unfinished one and carries the work holder to the opposite end of the table where it is put in place for the next operation. The machine weighs 6300 pounds, and was built by W. L. Sargent, of Fitchburg, Mass.



A SPECIAL DRILLING MACHINE

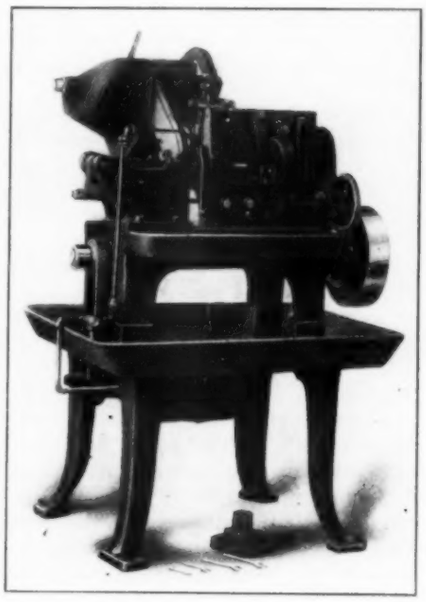
An Automatic Screw-slotting Machine

The accompanying illustrations show a new automatic screw-slotting machine which has recently been brought out for cutting the slots in the head of screw blanks and other work of a similar nature.

The machines are either mounted singly, as shown in Fig. 1, or in groups if a number are required, and are entirely automatic in their operations. All that is necessary is to keep the hoppers filled with blanks, from which they are automatically taken by a toggle carrier slide and held very rigidly in place while the saw, which is mounted in a swinging bracket, moves across the blank and cuts the slots. The bur which is formed by the saw is removed by a chip shaver, which passes under the head of the blank just as the saw returns to its original position.

The machine is driven through a friction clutch pulley and varying speeds for the handling of the different size screw blanks are obtained by a set of change gears which vary the timing of the operations of the machine.

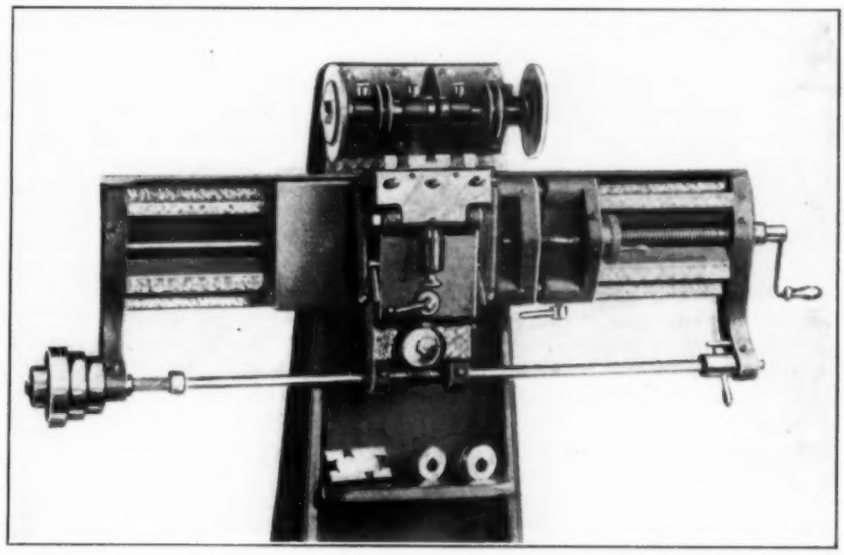
In order to flood the work with oil a substantial oil pump is provided, and there are also suitable guards for preventing chips and dirt getting into the machine itself and also provision for catching any drips and turning it to the oil tanks below the pan, which is under the legs of the machine itself. When machines are grouped together they are all driven from the single pulley and a single oil system furnishes the lubricant for all of the saws in the group. These machines are made by the Waterbury Farrel Foundry & Machine Company, Waterbury, Conn.



AUTOMATIC SCREW SLOTTER

A Gage-grinding Machine

The illustration shows the working part of a machine designed for grinding gages. It is mounted on a base and has two heads, one carrying an abrasive wheel for roughing and the other a diamond-charged lap for finishing. The work slide can be quickly moved from one lap to the other by means of the crank at the right of the slide support, while fine adjustment of the work for depth of cut is obtained by the indexed screw at the right of the work slide. Means are provided for swinging the work carrier forward for removal of work or for making measurements. The vertical slide is raised by a heart-shaped cam directly below it and the return motion is effected by two coiled springs. Provision is made for adjusting the hight of the work carrier to accommodate gages of different widths. A shield for protecting the cam and roll from grit, etc., is provided. The cam is cut with an increased feed at the top and bottom of the stroke. This is planned to prevent "bell mouthing" the work and does this effectually. Several cams, cut with different amounts of throw, are provided. The cam shaft is driven through a worm and gear, the worm being keyed to the lower shaft which carries a three-step cone pulley by means of which a change of speeds is obtained. Spindles, bearings and other working parts are made of hardened steel. The machine is made only to order by the Waltham Machine Works, Waltham, Mass., and the details can be changed to suit individual needs.



A GAGE-GRINDING MACHINE

Few persons outside of Ireland are aware of the extensive provision made for industrial education in Ireland. This matter is considered of such importance that no less than a million dollars is spent annually in this island for this object.

Pambour on the Locomotive

Among the interesting books which Henry R. Towne has presented to the library of the American Society of Mechanical Engineers is the volume by Chevalier F. M. G. d'Pambour, which was published in New York in 1832 by the *Railroad Journal*. Pambour was formerly a student of Ecole Polytechnique, a member of the royal artillery, and the information contained in his book was collected during a residence in England for scientific purposes.

While his experiments were crude, it must be remembered that he had none of the instruments of precision of the present day, and that neither the steam gage, the indicator nor the dynamometer had been invented. In fact it had been customary to consider the steam pressure as being constant throughout the stroke, but Pambour soon discovered that this was not the case. He used a spring balance in connection with the lever of the safety valve to measure the steam pressure, and constructed mercurial gages for this purpose. He also devised a large spring balance to be used for a dynamometer. Even in those days some of the engineers tightened up the safety valve so as to enable them to carry a higher pressure of steam and pull more cars or pull them more easily.

Pambour made a large number of tests on both engines and cars to determine their friction, and some of these experiments are extremely interesting. In some of his tests he determined the internal friction of the locomotive by finding what pressure of steam it was necessary to admit to the cylinders in order to move them, and some of them are reported to have run with only one pound pressure, which seems hardly credible from our later day experience. It is quite probable that the measure of pressure was incorrect, as in some of the later instances, notably locomotives Atlas and Sun, which had 12x16-inch cylinders, four coupled wheels 5 feet in diameter and weighed 11.4 tons; this pressure as measured by a mercurial gage was 4½ pounds.

Another of his methods of testing was to have the engine or car pulled by several men through a spring balance connected to the front of the locomotive or car. This was not entirely satisfactory as the fluctuations were considerable in most cases. These tests gave an average of 150 pounds for an engine weighing 8.34 tons, while on the locomotive "Sun," which weighed 7.9 tons, the average pull was only 100 pounds. It is rather curious to note in this connection that while the forward pull was only 100 pounds, it required a pull of 130 pounds to move this locomotive backward.

One of his most interesting tests was to let cars run by gravity on an incline which was divided into 34 parts of 10 chains each. Of these, the 16th post was 5280 feet from the start and was also 36.17 feet lower than the starting point. The 33d post was 10,560 feet, and was 38.77 feet below the starting point. His method was to start the cars at the top of the incline and see how far they would run, his reasoning being that the value of friction which stopped the car will be found by dividing the total hight from which it descends by the total distance traveled.

He decided that additional friction of the locomotive is in direct proportion to the load drawn, and he seemed to long for some instrument which would show the varying pressure in the cylinder, such as the indicator does today.

He worked out rules and formulas for all conditions and gave tables for sizes of locomotives to haul different loads. He designed a throttle valve which he called "a regulator," and his book shows blast pipes and discusses lead of the valve, larger steam pipes, calculations for leads, together with tests showing that small leads prove the best on the engines tested. Beginning with a lead of ⅛ inch he increased this gradually up to the point where the engine refused to run, and in most of the tests shown, this point is about ⅝ inch for these engines.

He shows the conical form of wheel tread, the elevation of rails on curves, and the effect of curves. He also takes up the effect of grades and adhesion, which he found to be always at least 1/20 of the weight, but he recommends for common practice 1/6 of the weight, which is not so far from our own practice as might be expected.

To show some of the refinement considered by Pambour, we must not overlook his tests showing that the consumption of fuel is in proportion to the load, and that the coal used per ton mile on the locomotives under test varied from .28 to .82 pounds. He also went into the expense account and gives the repairs per gross ton of locomotive at from 4c. to 16c., or an average of about 11c.

Nearly all of the engines tested were those built by Timothy Hackworth, of Darlington, who apparently assisted him in his experiments and coöperated with him in every way possible, showing his interest in the refinement and improvement of the locomotive even at that early day.

Business Items

Chas. A. Schieren Company, New York, are celebrating their fortieth anniverary, they having begun business in 1868.

Patterson, Gottfried & Hunter, Ltd., New York, will move about June 1 to 211-213-215 Centre street, a few hundred feet from their present store.

Charles G. Smith Company, Pittsburg, Penn., state that the report that they are going out of the machine tool business is incorrect.

George V. K. Greene has opened a consulting engineering office at 150 Nassau street, New York, and would like to receive catalogs of manufacturers.

A. E. Newlands, managing director, Newlands Brothers, Ltd., Sydney, New South Wales, Australia, manufacturers of metallic bedsteads, is in this country purchasing equipment for a new plant.

The Pittsburg (Penn.) Automatic Vise and Tool Company has received the contract for the complete bench equipment for vises for the Schoen Steel Wheel Company's new plant at Newlay, Yorkshire, England.

In order to provide for the very heavy demand for Edison lamps, and to take care of the new developments in Gem, Tantalum and Tungsten lamps, the General Electric Company has in the past year built four new factories at East Boston, Toledo, Ohio, Fort Wayne, Ind., and Newark, N. J.

Trade Catalogs

Wagner Electric Company, St. Louis, Mo. Pamphlet entitled "A Phase of the Panic." Illustrated, 4 pages, 6x9 inches.

Dahlstrom Metallic Door Company, Jamestown, N. Y. Catalog describing steel moldings. Illustrated, 12½x14 inches.

E. J. Flather Manufacturing Company, Nashua, N. H. Circular illustrating and describing automatic gear cutting machines.

Chicago Flexible Shaft Company, Chicago, Ill. Catalog describing Stewart gas blast furnaces. Illustrated, 56 pages, 9x11 inches, paper.

Eberhardt Brothers Machine Company, Newark, N. J. Circulars illustrating and describing automatic gear cutting machines for spur gears.

Baldwin Locomotive Works, Philadelphia, Penn. Record No. 64 on locomotives for the Central Railroad of Brazil. Illustrated, 32 pages, 6x9 inches, paper.

Park Drop Forge Company, Cleveland, land, Ohio. Short Stories about Steel. Early history of iron making in England and Dud Dudley and the invention of smelting with coal.

Hardinge Brothers, 1034-1040 Lincoln avenue, Chicago, Ill. Catalog of Cataract precision bench lathe and attachments, milling machine, etc. Illustrated, 98 pages, 7x10 inches, paper.

Standard Steel Works Company, Philadelphia, Penn. Pamphlet entitled "Steel Tires—Causes of Defects and Failures," which is a paper by George L. Norris read before the Western Railway Club. Illustrated, 38 pages, 6x9 inches, paper.

Manufacturers

The Pittsburg (Penn.) Safe Company will locate a factory in Sunnyvale, Cal.

The Salina (Kan.) Foundry and Manufacturing Company will enlarge its plant.

The Phœnix Foundry and Machine Company, Springfield, Mo., will erect a foundry 50x87 feet.

The Kellogg Car Equipment Company, Chicago, Ill., has purchased site for a car-repairing plant.

J. Regester's Sons Company, Baltimore, Md., will rebuild brass works recently destroyed by fire.

The Barr Hardware Company, Greenville, S. C., will erect an addition to be used as an altomobile repair shop.

Brown & Clossey, Montpelier, Vt., manufacturers of pneumatic tools, will move their plant to Burlington, Vt.

The Conley Frog and Switch Company, Memphis, Tenn., will erect an addition to its plant to cost about $20,000.

The principal shops of the Simmen Automatic Railway Signal Company will be moved from Los Angeles, Cal., to Perris.

Winters, Parsons & Boomer, with headquarters in Spokane, Wash., will erect machine and repair shops in Yardley.

The Chicago, South Bend and Northern Indiana Railway Company will build repair shop and car barns at South Bend.

Fire destroyed the plant of the Danvers (Mass.) Iron Works, owned by the Sylvester Company, of Boston. Loss $12,000.

The Bridgeport (Ala.) Woodenware Company will establish a plant at Selma for the manufacture of baskets, boxes, crates, etc.

The Crawfordsville (Ind.) Corrugated Culvert Company has been incorporated to manufacture steel culverts. P. O. Rudy, president.

The Fort Smith (Ark.) Well Drill Manufacturing Company has been incorporated with $25,000 capital. S. L. Johnson, president.

The Santa Fe & Southern Pacific Railroad will soon begin work on construction shops at San Rafael, Cal. About $600,000 will be expended.

F. W. Dodd, Des Moines, Iowa, formerly with the Des Moines Bridge and Iron Works, will establish a plant for the manufacture of structural steel.

The main plant of the Southern Car Company at High Point, N. C., was destroyed by fire, causing a loss of over $80,000. The plant will be rebuilt.

It is reported that the Ardmore (Okla.) Foundry, Machine and Boiler Company, will establish a rolling mill in Fort Smith, at a cost of about $200,000.

M. F. Young, connected with the Marion County Lumber Company, Marion, S. C., contemplates establishing foundry, machine shop and woodworking plant at Dillon, S. C.

Plans are being prepared for a new plant for the Columbus (Ohio) Lithograph Company, which will consist of an envelope factory, machine shop and lithograph building.

The Gross Gas and Electric Fixture Company, St. Louis, Mo., has been incorporated to manufacture gas and electrical fixtures. E. L. Gross, Fred Carr and others, incorporators.

The American Peanut Harvester Company, Petersburg, Va., has been incorporated with $50,000 capital to manufacture machinery for harvesting peanuts. H. R. Percivall, president.

The New Process Casting and Metal Company, Memphis, Tenn., has been incorporated by H. G. Undersood, H. B. White, W. S. Brian and others, for the purpose of establishing foundry and machine shop. Capital, $50,000.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith Co., Columbia, Pa.

If you use small gears in large quantities, write Berry and Parker, Erie, Pa.

Draftsmen office agents wanted for new style tools. D. J. Kelsey, New Haven, Conn.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACHINIST.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Designing and drafting of tools, special and general machinery. A. L. Nacke, 1211 Cherry St., Philadelphia, Pa.

New English patent act; manufacturing firm, equipped with modern plant, is prepared to negotiate with foreign holders of English patents with a view to undertaking their manufacture; preferably machine tools. Address Box 882, AMERICAN MACHINIST.

Special machinery designed and built; duplicate parts, tools, jigs and dies. The Wade Machine Co., 133 Oliver St., Boston.

Special machinery accurately built. Screw machine and turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Special machines designed and built; duplicate parts, model or experimental work. Mantle, Park ave. and 129th St., New York.

Automatic machinery designed; special purpose machines; working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Inventions, novelties, ideas, etc., developed; special machines designed. Albert Pott, M. E., 23 Platt St., New York, and Waterbury, Conn.

If you have a copy of March 7, 1907 AMERICAN MACHINIST we'll give you fifteen cents for it. AMERICAN MACHINIST, 505 Pearl St., New York.

Wanted—Exclusive sales agency for New York territory for some standard machine, tool, steam, or electrical specialty. Box 868, AMERICAN MACHINIST.

Special machinery designed, new ideas developed to practical results; tell me the conditions you wish to improve and I will do the rest. Box 877, AMERICAN MACHINIST.

Chauffeurs earn good wages; call and take a trial lesson at our garage; we do not wish you to enroll unless you like our method of instruction; booklet free. Automobile School, 754 South Broad St., Philadelphia.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Machinery built to order and by contract; special parts made; gear cutting, automobile and pattern work, punch press and screw machine work, tools, dies, etc. Blair Tool and Machine Works, West and Morris Sts., New York City.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

New British patent laws; high class engineering firm with modern plant is open to quote favorable terms for building engineering specialties or machine tools in England. The Simplex Engineering Co., Ltd., Trafford Park, Manchester.

Wanted—By a man of manufacturing and technical experience, willing to furnish some capital, a patented machine or device or other good manufacturing proposition, sharing good possibilities; able to manufacture and sell to good advantage. Box 883, AM. M.

A firm of five mechanical engineers having well appointed offices in the largest office building in Chicago desire to connect with one or more eastern manufacturers with a view of representing them in Chicago; interested parties please address Rooms 452-453 Monadnock Block, Chicago.

In evenings, invent for profit; mail invention for free advice, and cost to obtain a patent; popular prices; open day and evening. Edward P. Thompson, M. E., registered patent attorney, member A. S. M. E., and A. I. E. E., 50 and 53 Morningside Ave., West, New York, via subway to Columbia University station.

Foreign Representative — Mechanical engineering graduate of a leading Eastern institute, who has had several years of practical experience here and abroad, desires to act as foreign representative of a reliable engineering and manufacturing concern. Party prepared to furnish best of financial and foreign references. Owing to possible important confidential communications, private interviews are desired, with any concern prepared to furnish an A1 business proposition. Box 891, AMERICAN MACHINIST.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

ILLINOIS

Draftsman, experienced in design of electrical and hydraulic apparatus, gas and steam engines. Box 869, AMER. MACHINIST.

Assistant superintendent manufacturing plant 3 years; 5 years' previous experience in machine shop and drafting room; 32 years old; Yale graduate; member of A. S. M. E.; location, in or near Chicago. Box 732, AMERICAN MACHINIST.

INDIANA

Up-to-date executive, producer, organizer, systematic, experienced on machine tools, engines and mill repair will be ready to change soon. Box 871, AMERICAN MACHINIST.

MASSACHUSETTS

General foreman will be at liberty March 1; A-1 designer of tools, jigs, etc. Box 873, AMERICAN MACHINIST.

Position as superintendent or general foreman by an experienced mechanic; electrical machinery, air compressors, or machine tools. Box 878, AMERICAN MACHINIST.

Technical graduate, nine years in telephone, telegraph, submarine cable, and signalling lines, wishes position; have had wide, general experience in development, designing, manufacturing, installation, and as representative. Box 887, AMERICAN MACHINIST.

NEW YORK

Mechanical draftsman and engineer, desires position anywhere. Years of experience. Technical, Box 900, AMERICAN MACHINIST.

Tool designer, 30 years, college graduated, 12 years' practical and office experience, A1 references, desires position. Box 898, AMERICAN MACHINIST.

Young man, successful designer and draftsman, familiar with shop practices, desires position. Correspondence invited with firms desiring a man of good ability and industry. Box 899, AMERICAN MACHINIST.

Draftsman wishes change; technical graduate, four years in machine shop, has had experience in erecting machinery; specially interested in gas engines, has studied latter abroad. Box 892, AMERICAN MACHINIST.

Foreman toolmaker or master mechanic desires change; location Greater New York or vicinity; expert on tools, jigs, fixtures and special machine design; well up in modern shop; practical and successful handler of men; reasonable salary. Address Box 842, AMERICAN MACHINIST.

Wanted—Position by foundry foreman; young, strictly temperate in habits, well up in cupola practice and mixing iron and brass; thoroughly understands equipping and organizing new foundries; can furnish best of references; willing to go anywhere. Box 881, AMERICAN MACHINIST.

OHIO

Mechanical draftsman and designer; college graduate; 7 years' experience on general machinery, hoisting machinery specialty, wants position; highest references. Box 885, AMERICAN MACHINIST.

Situation Wanted—Mechanical engineer; successful as a practical inventor and constructing engineer; experienced in gas, refrigeration, air, steam and hydraulic engineering, etc.; has invented and developed large variety of machinery now in general use; advertiser is a university graduate; a practical machinist; has had twenty years' experience in mechanical engineering; is of course now fully occupied, but desires to make a change for good reasons, and invites correspondence; only the highest class position in the engineering sense is desired; any location satisfactory. Box 847, AMERICAN MACHINIST.

PENNSYLVANIA

Draftsman and designer with shop experience and executive ability; desires position; Philadelphia or vicinity. Box 896, AMERICAN MACHINIST.

Mechanical engineer and draftsman; college graduate; all-around man; 8 years' experience in designing of machinery and plants; desires to change present position. Box 864, AMERICAN MACHINIST.

Mechanical draftsman wishes position; college graduate, Sweden, 4 years ago; 2½ years' experience in Germany on steam en-

gines, 1 year in United States on heavy machinery; moderate salary. Box 884, AM. M.

Help Wanted

Classification indicates present address of advertiser, nothing else.

ILLINOIS

Wanted—Expert engineer and draftsman as leading designer of special labor-saving machinery by Western manufacturing firm employing about 300 men; good salary to first-class, experienced man giving good references; none other need apply. Box 886, AMERICAN MCHINIST.

MASSACHUSETTS

Wanted—First-class foreman for machine work on brass castings; also foreman for machine shop on general and small work. Box 872, AMERICAN MACHINIST.

MINNESOTA

Wanted—A first-class foreman for machine department; young, progressive man preferred. Must be good mechanic and hustler. Splendid opportunity in shop located in the Northwest. Box 889, AMERICAN MACHINIST.

MISSOURI

Superintendent wanted; experienced in building gas engines; good mechanic executive; one who can invest. Miners Gas Engine and Mfg. Co., Joplin, Mo.

NEW YORK

Wanted—A first-class draftsman and designer. State education, experience and salary expected. Box 894, AMERICAN MACHINIST.

Wanted—Mechanical draftsman; one who has had some experience at designing; must be a good detailer and copyist and willing to do that class of work; technical graduate preferred; state age, salary, etc. "Detailer," care AMERICAN MACHINIST.

Experienced foreman wanted to take charge of milling and drilling department in typewriter factory. Must be good mechanic and executive, with wide experience in similar work. Write particulars and salary desired to Box 893, AMERICAN MACHINIST.

Young man with mechanical experience to look up new business in large city; must be capable of designing machines for special purposes, and competent to estimate on new work; good opening and permanent position for competent party. Address stating age, references, salary expected, and full particulars as to experience. Box 888, AM. MACH.

General foreman for shop employing 50 to 75 men on special machinery, machine tools, and general jobbing; must be first-class mechanic and good executive, familiar with modern shop methods, systematic, and have the right personality and push to produce results at minimum cost; give full particulars as to experience, age, nationality, salary expected and references. Box 866, AM. MACH.

Superintendent with experience and good executive ability, capable of taking full charge of the manufacturing end of a modern plant employing 250 men in the manufacture of a line of A-1 machine tools; location, a pleasant town of 10,000 inhabitants, moderate rents, etc.; this is a good opportunity for the right man; state age, experience and salary expected, with references. Address "Manufacturer," AMERICAN MACHINIST.

Wanted—Managing foreman; young man who is successfully filling similar position, but is desirous of advancing, and can handle 300 men from castings to finished product on plain and high speed engines 3 to 300 horse-power, pumps and similar work; state in full, length of time each position, responsibilities, results, references and salary wanted to start; excellent opportunity for a young man of executive ability for advancement. Box 974, Buffalo, N. Y.

OHIO

Premium work system man. Must be mechanic and competent to fix rate of piece production and make system a success. Box 890, AMERICAN MACHINIST.

PENNSYLVANIA

Wanted—A general foreman, one who is experienced in all branches of engine work; applicant must be a hustler, thoroughly familiar with modern shop methods, able to handle men and show a clean record from past employers. Riverside Engine Company, Oil City, Pa.

Engineer and draftsman with thorough experience in the designing of air compressors and air compressing machinery in general; good position with chance to advance for the right man; first letter must give full details as to past experience along this line, age and salary expected, also present employment; all replies treated confidentially. "Compressors," AMERICAN MACHINIST.

FOREIGN

Wanted—A chief constructing engineer for high tension switches by a large German firm, manufacturing electrical supplies; engineers who have been engaged for a considerable time in managing construction work in this line and who speak and write the German language fluently, are requested to address applications, with a brief description of their previous experiences, statement of reference, time when they will be able to enter upon their duties and expectations as to salary, to J. Z. 9861, care Rudolf Mosse, Annoncen-Expedition, Berlin, S. W.

For Sale

For Sale—Foundry, wood and iron machine shop; all equipped. Box 74, Albion, N. Y.

For Sale—The right to manufacture the best tilting tumbling barrel out; covered by a good strong patent. Box 895, AMERICAN MACHINIST.

For Sale—Well equipped general machine shop in New Jersey; employing 15 to 20 hands; good reason for selling. R., Box 1216, New York City.

For Sale—An interest in a machine tool agency, controlling up-to-date line; making money; good territory. Reasons for selling and full particulars, apply Box 897, AMERICAN MACHINIST.

For Sale—Two brand new Brown & Sharpe automatic screw machines, one No. 0 and one No. 00, including all attachments for same. Rockford Automobile & Engine Co., Rockford, Ill.

Patents for sale; an inexpensive bevel and mitre gear cutting attachment for use with a shaper; will unquestionably do a class of work which has heretofore been possible only with very high priced special machines. Address W. W. Clippinger, 80 Atlas Bank Bldg., Cincinnati, Ohio.

Alphabetical Index to Advertisers

	PAGE
Abrasive Material Co.	82
Acme Machinery Co.	68
Adams Co.	67
Albro-Clem Elevator Co.	74
Almond Mfg. Co., T. R.	80
Alteneder & Son, Theo.	87
American Emery Wheel Wks.	45
American Gas Furnace Co.	53
American Pulley Co.	78
American School of Correspondence	25
American Tool & Machine Co.	72
American Tool Works Co., 8 and	92
American Tube & Stamping Co.	97
American Wood Working Machinery Co.	68
Armstrong Blum Mfg. Co.	77
Armstrong Bros. Tool Co.	91
Athol Machine Co.	65
Automatic Machine Co.	76
Backus Water Motor Co.	63
Baker Bros.	97
Bardons & Oliver	73
Barnes Co., B. F.	64
Barnes Co., W. F. & John	14
Barnett, G. & H.	38
Baush Machine Tool Co., 3d cover	
Bay State Stamping Co.	63
Beaman & Smith, 15 and	80
Becker-Brainard Milling Machine Co.	23
Bemis & Call Hardware & Tool Co.	68
Besly & Co., Chas. H.	66
Bethlehem Foundry & Mach Co.	72
Bethlehem Steel Co.	85
Bickford Drill & Tool Co.	10
Bignall & Keeler Mfg. Co.	76
Bilgram, Hugo	75
Billings & Spencer Co.	95
Binsee Machine Co.	38
Birdsboro Steel Fdry. & Mach. Co.	66
Blaisdell Machinery Co.	86
Blanchard Machine Co.	71
Bliss Co., E. W.	25
Blount Co., J. G.	83
Boston Gear Works	74
Boston Saw and Tool Co.	61
Bowsher & Co., N. P.	90
Boynton & Plummer	76
Bradford Machine Tool Co.	5
Bradley & Son, C. C.	63
Bridgeport Safety Emery Wheel Co.	82
Bristol Co. 4th cover	
Bristol, Wm. H.	38
Brown & Co., R. H.	80
Brown & Sharpe Mfg. Co., 4th cover	
Brown Hoisting Mchry. Co.	78
Brubaker & Bros., W. L.	76
Bullard Mach. Tool Co.	37
Burke Electric Co.	90
Burroughs Co., Chas.	70
C & C Electric Co.	88
Caldwell & Son Co., H. W.	75
Cammel, Laird & Co.	85
Carborundum Co.	6
Card Mfg. Co., S. W.	16
Carpenter Steel Co.	84
Carpenter Tap & Die Co., J. M.	72
Case Mfg. Co.	78
Cell Drier Machine Co.	84
Chambersburg Engineering Co.	68
Champion Tool Works Co.	76
Chicago Flexible Shaft Co.	86
Chicago Pneumatic Tool Co.	88
Chicago Raw Hide Mfg. Co.	61
Cincinnati Elec. Tool Co.	67
Cincinnati Lathe & Tool Co.	76
Cincinnati Machine Tool Co.	24
Cincinnati Milling Machine Co.	7
Cincinnati Planer Co.	26
Cincinnati Shaper Co.	98
Clark Cast Steel Cement Co.	85
Clayton Air Compressor Wks.	86
Cleveland Auto. Mach. Co.	18
Cleveland Cap Screw Co.	61
Cleveland Crane & Car Co.	73
Cleveland Planer Works	79
Cleveland Twist Drill Co., 4th cover	
Cleveland Wire Spring Co.	72
Clough, R. M.	74
Coates Clipper Mfg. Co.	73
Cochrane-Bly Co.	1
Coes Wrench Co.	14
Colburn Machine Tool Co.	25
Cook Co., Asa S.	76
Consolidated Press and Tool Co.	70
Cowanesque Valley Iron Works	79
Crescent Forgings Co.	69
Crocker-Wheeler Co.	90
Crosby Steam Gage & Valve Co.	17
Curtis & Co. Mfg. Co	79
Curtis & Curtis Co.	61
Cushman Chuck Co.	80
Davis Machine Co., W. P.	94
Desmond-Stephan Mfg. Co.	82
Detrick & Harvey Mach. Co.	61
Diamond Chain & Mfg. Co.	77
Diamond Machine Co.	38
Dickinson, Thos. L.	82
Dietz Machine Works	87
Dill Slotter People	70
Dixon Crucible Co., Jos.	63
Dreses Machine Tool Co.	9
Earle Gear & Mach. Co.	74
Eastern Machinery Co.	77
Eberhardt Bros. Mach. Co.	74
Eck Dynamo and Motor Co.	90
Elmes Engineering Works, Co., Chas. F.	76
Emmert Mfg. Co.	95
Errington, F. A.	81
Evans Friction Cone Co.	69
Excelsior Needle Co.	70
Farrel Fdry. & Machine Co.	85
Fawcus Machine Co.	74
Fay Machine Tool Co.	97
Fellows Gear Shaper Co.	51
Ferracute Machine Co.	77
Firth-Sterling Steel Co.	83
Fitchburg Machine Wks.	31
Flather Planer Co., Mark	86
Foote-Burt Co., The	91
Fosdick Machine Tool Co.	16
Franklin Mfg. Co., H. H.	83
Fulton Machine & Vise Co.	95
Gang Co., Wm. E.	76
Gardner Machine Co.	82
Garvin Machine Co.	94
Gem Mfg. Co.	72
General Electric Co.	88
General Pneumatic Tool Co.	79
Geometric Tool Co.	27
Gisholt Machine Co.	97
Gleason Works 4th cover	
Globe Machine & Stamping Co.	63
Goldschmidt Thermit Co.	85
Gorton Machine Co., Geo.	70
Gould & Eberhardt	60
Graham Mfg. Co.	95
Grant Gear Wks.	74
Grant Mfg. and Machine Co.	70
Gray Co., G. A.	32
Gray & Prior Machine Co.	71
Greaves, Klusman & Co.	71
Grönkvist Drill Chuck Co., 80 and	91
Hammacher, Schlemmer Co.	55
Hardinge Bros.	76
Harrison & Knight Mfg. Co.	76
Harrington, Son & Co., Edw.	79
Hart & Cooley Co.	27
Hart Mfg. Co.	68
Heald Machine Co.	91
Hendey Machine Co.	53
Henry & Wright Mfg. Co.	65
Hill, Clarke & Co., Inc.	93
Hill Publishing Co. 62 and	94
Hisey-Wolf Machine Co.	30
Hoefer Mfg. Co.	73
Hoggson & Pettis Mfg. Co.	81
Horsburgh & Scott Co.	74
Horton & Son Co., E.	80
Hunt Co., Robt. W.	61
Hurlbut-Rogers Machine Co.	61
Industrial Oxygen Co.	85
Ingersoll Milling Machine Co.	30
Ingersoll-Rand Co.	87
Jacobs Mfg. Co.	81
Jantz & Leist Elec. Co.	90
Jenkins Bros.	63
Johnson Machine Co., Carlyle	47
Jones & Lamson Mach. Co., 12, 13 and	38
Juengst & Sons, George	64
Kearney & Trecker	69
Kelly Co., R. A.	73
Kempsmith Mfg. Co.	22
Kern Machine Tool Co.	65
Kilbourne & Jacobs Mfg. Co.	63
L. & D. Co.	61
Landis Machine Co.	71
Landis Tool Co.	47
Lapointe Machine Tool Co.	71

	PAGE
Lea Equipment Co.	60
LeBlond Machine Tool Co., R. K. ....4th cover	
LeCount, Wm. G.	81
Link Belt Co.	86
Lodge & Shipley Machine Tool Co.	4
Long & Allstatter Co.	68
Lucas Machine Tool Co.	96
Lumen Bearing Co.	84
Lunkenheimer Co.	63
Lyon Metallic Mfg. Co.	72
Machine Screw Products Co.	73
Manning, Maxwell & Moore, Inc.	78
Manufacturers Equipment and Engineering Co.	73
Manville Bros. Co.	17
Maris Bros.	78
Marshall & Huschart Mch. Co.	92
Massachusetts Saw Works	91
McCabe, J. J. ....32 and	92
Merritt, Jos.	61
Merritt & Co.	77
Metal Hardening Solution Co.	84
Milton Mfg. Co.	53
Miner & Peck Mfg. Co.	76
Monarch Emery & Cor. Wheel Co.	82
Moore Co., Franklin	78
Morse Chain Co.	64
Morse Twist Drill & Mach. Co.	49
Morse, Williams & Co.	75
Morton Mfg. Co.	77
Mossberg Wrench Co.	77
Motch & Merryweather Machine Co.	93
Mueller Mach. Tool Co.	71
Mumford Co., E. H.	77
Mummert, Wolf & Dixon Co.	61
National Acme Mfg. Co.	98
National Machinery Co.	77
Neptune Meter Co.	85
New Britain Mach. Co.	70
New Haven Mfg. Co.	71
New Process Raw Hide Co.	75
Newton Machine Tool Works	11
Nicholson File Co.	17
Nicholson & Co., W. H.	96
Niles-Bement-Pond Co., 33, 34, 35, 36 and	93
Nolte Brass Co.	63
Northern Elec. Mfg. Co.	88
Northern Engineering Works	78
Norton Co.	59
Norton Grinding Co.	30
Nuttall Co., R. D.	74
Obermayer Co., S.	84
O. K. Tool Holder Co.	61
Owen Mach. Tool Co.	22
Parker Company, Chas.	95
Patterson, Gottfried & Hunter, Ltd.	90
Pawling & Harnischfeger	78
Paxson Co., J. W.	79
Philadelphia Bourse	69
Philadelphia Gear Works	74
Pittsburg Auto. Vise & Tool Ltd.	95
Potter & Johnston Mach. Co., 20 and	21
Pratt Chuck Co.	80
Pratt & Whitney Co. ....2 and	3
Prentice Bros. Co.	29
Prentiss Tool & Supply Co., 92 and	94
Q. C. Machine Tool Co.	77
Reed Co., F. E.	60
Reed Mfg. Co.	95
Reichheim & Co., E. P.	72
Ridgway Dynamo & Engine Co	89
Rivett-Dock Co. ....3d cover	
Rivett Lathe Mfg. Co. ...3d cover	
Rockford Drilling Machine Co.	64
Rock Island Tool Co.	95
Rockwood Mfg. Co.	79
Rogers & Hubbard Co.	84
Rogers Wks., John M.	71
Roth Bros. & Co.	90
Rowell Co., W. G.	85
Royersford Foundry & Mach. Co.	77
Safety Emery Wheel Co.	82
Saunders Sons, D.	73
Saunders' Sons, James	67
Sawyer Gear Wks.	74
Schieren Co., Chas. A.	91
Schmitz, August	69
Schumacher & Boye	9
Seaver, John W.	72
Sebastian Lathe Co.	27
Sellers & Co., Inc., Wm.	28
Seneca Falls Mfg. Co.	67
Shultz Belting Co.	77
Sibley Mch. Tool Co.	68
Simonds Mfg. Co. ....76 and	77
Skinner Chuck Co.	80
Slate Machine Co., Dwight	69
Sloan & Chace Mfg. Co.	59
Slocomb Co., J. T.	68
Smith, Chas. F.	76
Smith Countershaft Co.	31
Smith & Mills	76
Smith Co., Wm. J.	66
Spacke Mach. Co., F. W.	87
Springfield Mach. Tool Co.	15
Standard Connecting Rod Co.	63
Standard Engineering Works	61
Standard Gauge Steel Co.	75
Stark Tool Co.	77
Starrett Co., L. S.	45
Steptoe Shaper Co., John	81
Stoever Foundry & Mfg. Co.	83
Sturtevant Co., B. F.	24
Tabor Mfg. Co.	98
Taylor & Fenn Co.	69
Taylor-Wilson Mfg. Co.	74
Toomey, Frank	93
Triumph Electric Co.	89
Trump Bros. Machine Co.	81
Tudor Mfg. Co.	90
Turner Brass Works	61
Underwood & Co., H. B.	78
Union Twist Drill Co.	57
Universal Machine Screw Co.	65
U. S. Eectrical Tool Co.	90
Van Dorn & Dutton	74
Vandyck Churchill Co.	66
Vitrified Wheel Co.	82
Von Wyck Mach. Tool Co.	77
Walcott & Wood Mach. Tool Co.	76
Waltham Watch Tool Co.	94
Ward & Sons, Edgar T.	84
Warner & Swasey Co.	96
Warner Instrument Co.	70
Waterbury Farrel Fdry. & Mach. Co.	73
Watson-Stillman Co.	87
Western Electric Co.	89
West Haven Mfg. Co.	77
Westinghouse Elec. & Mfg. Co.	89
Westmacott Gas Furnace Co.	61
Weston Elec. Instrument Co.	90
Whitcomb-Blaisdell Machine Tool Co. ....10 and	94
Whitman & Barnes Mfg. Co.	51
Whitney Mfg. Co.	43
Whiton Machine Co., D. E.	80
Wiley & Russell Mfg. Co.	69
Williams & Co., J. H.	91
Williamson Vise Co.	95
Wilmarth & Morman Co.	82
Woodward & Powell Planer Co.	61
Worcester Machine Screw Co.	61
Wormer Machinery Co., C. C.	94
Yale & Towne Mfg. Co.	78

Classified Index to Articles Advertised

Abrasive Materials

Abrasive Material Co., Phila., Pa.
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Carborundum Co., Niagara Falls, N. Y.
Monarch Emery & Cor. Wheel Co., Camden, N. J.
Norton Co., Worcester, Mass.
Safety Emery Wheel Co., Springfield, O.
Vitrified Wheel Co., Westfield, Mass.

Aftercoolers, Air

Ingersoll-Rand Co., New York.

Air Lifts

Ingersoll-Rand Co., New York.

Alundum

See Grinding Wheels.

Arbor Presses

Barnes Co., W. F. & John, Rockford, Ill.
Marshall & Huschart Machinery Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Wilmarth & Morman Co., Grand Rapids, Mich.

Arbors

Cleveland Twist Drill Co., Cleveland, O.
Cochrane-Bly Co., Rochester, N. Y.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Union Twist Drill Co., Athol, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Architects

Seaver, John W., Cleveland, O.

Balancing Ways

Bowsher Co., N. P., South Bend, Ind.

Barrels, Steel

Cleveland Wire Spring Co., Cleveland, O.
Kilbourne & Jacobs Mfg. Co., Columbus, Ohio.
Lyon Metallic Mfg. Co., Aurora, Ill.

Barrels, Tumbling

Globe Machine & Stamping Co., Cleveland, O.

Bars, Boring

Beaman & Smith Co., Prov., R. I.
Cleveland Twist Drill Co., Cleveland, O.
Elmes Engineering Works, Chas. F., Chicago, Ill.
Mathews, Hugh, Kansas City, Mo.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Bearings, Ball and Roller

Boston Gear Works, Norfolk Downs, Mass.
Hyatt Roller Bearing Co., Harrison, N. J.
Standard Roller Bearing Co., Philadelphia, Pa.

Belt Dressing

Cling-Surface Mfg. Co., Buffalo, N. Y.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Schieren Co., Chas., A., New York.
Shultz Belting Co., St. Louis, Mo.

Belt Fasteners

Bristol Co., Waterbury, Conn.

Belt Filler

Schieren Co., Chas., A., New York.
Shultz Belting Co., St. Louis, Mo.

Belt Lacing Machine

Birdsboro Steel Foundry & Mach. Co., Birdsboro, Pa.

Belt Shifters

The L. & D. Co., Boston, Mass.

Belting, Leather

Schieren Co., Chas., A., New York.
Shultz Belting Co., St. Louis, Mo.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Benches, Work

Manufacturing Equipment & Engineering Co., Boston, Mass.

Bending Machinery, Hydraulic

Niles-Bement-Pond Co., New York.
Watson-Stillman Co., New York.

Bending Machinery, Plate

Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

Bending Machinery, Power

Bethlehem Foundry and Machine Co., South Bethlehem, Pa.
Boynton & Plummer, Worcester, Mass.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Bending Tools, Hand

Estep & Dolan, Sandwich, Ill.
Wallace Supply Co., Chicago, Ill.

Blanks, Nut and Screw

Whitman & Barnes Mfg. Co., Chicago, Ill.

Blocks, Chains

See Hoists, Hand

Blocks, Die

Nicholson & Co., W. H., Wilkes-Barre, Pa.

Blowers

American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
General Electric Co., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Roth Brothers & Co., Chicago, Ill.
Sturtevant Co., B. F., Hyde Park, Mass.

Blue Print Machines

General Electric Co., New York.

Blue Print Paper

Keuffel & Esser Co., New York.

Bolt and Nut Machinery

Acme Machry. Co., Cleveland, O.
Boynton & Plummer, Worcester, Mass.
Brown Co., H. B., East Hampton, Conn.

Bolt and Nut Machinery —*Continued.*

Davis Machine Co., W. P., Rochester, N. Y.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Landis Machine Co., Waynesboro, Pa.
Milton Mfg. Co., Milton, Pa.
Mummert, Wolf & Dixon Co., Hanover, Pa.
National-Acme Mfg. Co., Cleveland, O.
National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Engineering Works, Ellwood City, Pa.
Vandyck Churchill Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Bolt Heads

Lang Co., G. R., Meadville, Pa.

Bolts and Nuts

Cleveland Cap Screw Co., Cleveland, O.
Milton Mfg. Co., Milton, Pa.
National-Acme Mfg. Co., Cleveland, O.

Bone for Case Hardening

Rogers & Hubbard Co., Middletown, Conn.

Books, Technical

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
Piers, Frank, Phila., Pa.
Sames, Chas. M., Jersey City, N. J.

Boosters

Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Boring and Drilling Machines, Horizontal

Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Betts Mach. Co., Wilmington, Del.
Binsse Mach. Co., Newark, N. J.
Boynton & Plummer, Worcester, Mass.
Detrick & Harvey Mach. Co., Wilmington, Del.
Fitchburg Machine Works, Fitchburg, Mass.
Fosdick Mach. Tool Co., Cin., O.
Gisholt Mach. Co., Madison, Wis.
Lucas Mach. Tool Co., Cleveland, Ohio.
McCabe, J. J., New York.
Motch & Merryweather Machinery Co., Cleveland, O.
Newton Machine Tool Wks., Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Whitcomb-Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical

American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass
Betts Mach. Co., Wilmington, Del.
Bullard Mach. Tool Co., Bridgeport, Conn.
Colburn Mach. Tool Co., Franklin, Pa.
Gisholt Mach. Co., Madison, Wis.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
McCabe, J. J., New York.
Niles-Bement-Pond Co, New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Boring Tools

Armstrong Bros. Tool Co., Chicago, Ill.

Boxes, Tote

Cleveland Wire Spring Co., Cleveland, O.
Lyon Metallic Mfg. Co., Aurora, Ill.

Box Tools, Roughing

Bardons & Oliver, Cleveland, O.

Brackets, Lamp

Standard Welding Co., Cleveland, Ohio.

Brazing

Industrial Oxygen Co., New York.

Broaching Machines

Harrington, Son & Co., Edwin, Philadelphia, Pa.
Lapointe Mach. Tool Co., Hudson, Mass.

Bulldozers

National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.

Cabinets, Tool

Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Lyon Metallic Mfg. Co., Aurora, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Calipers

Athol Mach. Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Sawyer Tool Mfg. Co., Fitchburg, Mass.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Cams

Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum

See Grinding Wheels.

Carborundum Paper and Cloth

Carborundum Co., Niagara Falls, N. Y.

Case-Hardening

Rogers & Hubbard Co., Middletown, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Cast Iron Brazing

Industrial Oxygen Co., New York.

Castings, Brass and Bronze

Lumen Bearing Co., Buffalo, N. Y.
Neptune Meter Co., Long Island City, N. Y.
Rowell Co., W. G., Bridgeport, Ct.

Castings, Die Molded

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Castings, Iron

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Cell Drier Machine Co., Taunton, Mass.
Farrel Fdry. & Mach. Co., Ansonia, Conn.

Castings, Steel

Bethlehem Steel Co., So. Bethlehem, Pa.
Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Cammel, Laird & Co., New York.
Carpenter Steel Co., Reading, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Farrel Fdry & Mach. Co., Ansonia, Conn.

Cement, Cast Steel

Clark Cast Steel Cement Co., Shelton, Conn.

Centering Machines

Hendey Mach. Co., Torrington, Conn.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer

Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving

Boston Gear Works, Norfolk Downs, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
Whitney Mfg. Co., Hartford, Ct.

Chisels, Cold

Whitman & Barnes Mfg. Co., Chicago, Ill.

Chucking Machines

American Tool Wks. Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Mach. Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Reed Co., F. E., Worcester, Mass.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

Chucks, Drill

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Brown & Co., R. H., New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Grönkvist Drill Chuck Co., Jersey City, N. J.
Horton & Son Co., E., Windsor Locks, Conn.
Jacobs Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Standard Tool Co., Cleveland, O.

Chucks, Drill—*Continued.*

Trump Bros. Mach. Co., Wilmington, Del.
Whitney Mfg. Co., Hartford, Ct.
Whiton Mach. Co., D. E., New London, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Chucks, Lathe

Cushman Chuck Co., Hartford, Conn.
Gisholt Mach. Co., Madison, Wis.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Son Co., E., Windsor Locks, Conn.
Niles-Bement-Pond Co., New York.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Ct.
Whiton Mach. Co., D. E., New London, Conn.

Chucks, Planer

Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.

Chucks, Split

Hardinge Bros., Chicago, Ill.
Rivett Lathe Mfg. Co., Boston, Mass.

Circuit Breakers

Crocker - Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps

Billings & Spencer Co., Hartford, Conn.
Hammacher, Schlemmer & Co., New York.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Starrett Co., L. S., Athol, Mass.
Tudor Mfg. Co., Taunton, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Clutches, Friction

Caldwell, Son & Co., H. W., Chicago, Ill.
Cowanesque Valley Iron Wks., Cowanesque, Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.

Coal Handling Machinery

Link-Belt Co., Philadelphia, Pa.

Coils

Standard Welding Co., Cleveland, Ohio.

Collets and Attachments, Spring

Adjustable Collet Co., Cleveland, Ohio.

Compound, Core

Obermayer Co., S., Cincinnati, O.

Compound, Pipe Joint

Dixon Crucible Co., Joseph, Jersey City, N. J.

Compressors, Air

Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Cambridge, Mass.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Sampson & Co., Geo. H., Boston, Mass.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas

Blaisdell Machinery Co., Bradford, Pa.

Cones, Friction

Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps

Bethlehem Steel Co., So. Bethlehem, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work

Blanchard Mach. Co., Cambridge, Mass.
Cell Drier Machine Co., Taunton, Mass.
Dietz Machine Works, Phila., Pa.
Ingle Machine Co., Rochester, N. Y.
Manville Bros. Co., Waterbury, Conn.
Merritt, Jos., Hartford, Conn.
Turner Mach. Co., Danbury, Ct.

Controllers and Starters, Electric Motor

Case Mfg. Co., Columbus, O.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic

Link-Belt Co., Philadelphia, Pa.

Coping Machines

Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Corundum

See Grinding Wheels.

Cotters

Adjustable Collet Co., Cleveland, Ohio.
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores

Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Counters, Machinery

Veeder Mfg. Co., Hartford, Ct.

Countershafts

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders Iron Foundry, Providence, R. I.
Coates Clipper Mfg. Co., Worcester, Mass.
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Mossberg Wrench Co., Central Falls, R. I.
Norton Grinding Co., Worcester, Mass.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction

Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing

Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose

Ingersoll-Rand Co., New York.

Couplings, Shaft

Almond Mfg. Co., T. R., Brooklyn, N. Y.

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It also cuts Key Seats automatically for the Woodruff Patent System of Keying.

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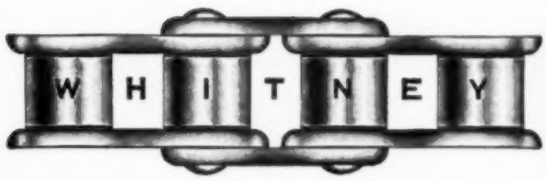

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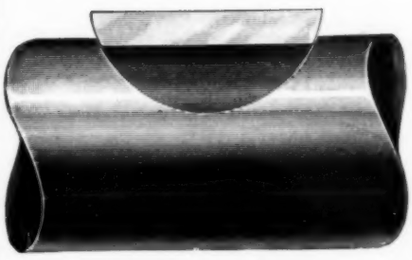

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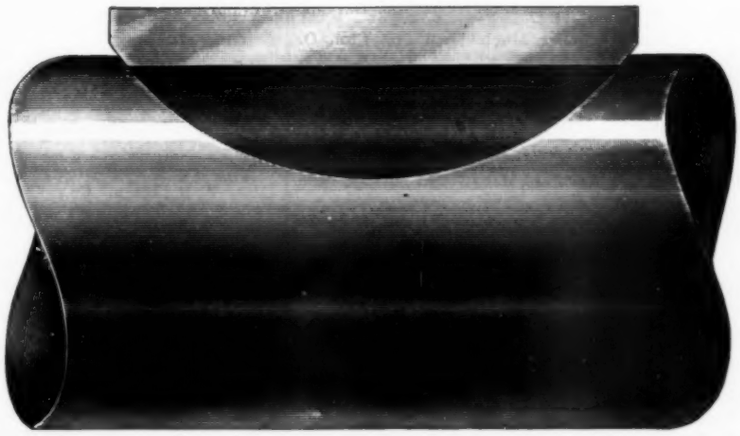

The Whitney Mfg. Co.,

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Couplings, Shaft—*Continued.*
Caldwell & Son Co., H. W., Chicago, Ill.
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Link-Belt Co., Philadelphia, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.

Cranes
Brown Hoisting Mach. Co., Cleveland, O.
Case Mfg. Co., Columbus, O.
Chicago Pneumatic Tool Co., Chicago, Ill.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Manning, Maxwell & Moore, Inc., New York.
Maris Bros., Philadelphia, Pa.
Moore Co., Franklin, Winsted, Ct.
Nicholls, Wm. S., New York.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co. New York.

Crank Pin Turning Machines
Niles-Bement-Pond Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Crank Shafts
Bethlehem Steel Co., So. Bethlehem, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles
Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas, and Ladles, Foundry
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups and Covers, Oil
Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co, Cincinnati, O.
Winkley Co., Detroit, Mich.

Cups, Grease
Lunkenheimer Co., Cincinnati, O.

Cutters, Milling
Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Hardinge Bros. Chicago, Ill.
Harrison & Knight Mfg. Co., Newark, N. J.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines
Armstrong Bros. Tool Co., Chicago, Ill.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.

Cutting-off Machines—*Cont.*
Brown & Sharpe Mfg. Co., Providence, R. I.
Davis Machine Co., W. P., Rochester, N. Y.
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Newton Mach. Tool Wks., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Schmitz, August, Dusseldorf, Germany.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.
Western Tool & Mfg. Co., Springfield, O.

Diamond Tools
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.

Dies, Sheet Metal
American Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Consolidated Press and Tool Co., Hastings, Mich.
Ferracute Mach. Co., Bridgeton, N. J.
Globe Machine & Stamping Co., Cleveland, O.
Manville Bros. Co., Waterbury, Conn.

Dies, Sub-Press
Sloan & Chace Mfg. Co., Newark, N. J.
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Opening
Errington, F. A., New York.
Foote-Burt Co., Cleveland, O.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Machine Co., Springfield, Vt.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins
Winkley Co., Hartford, Conn.

Drawing Boards and Tables
Alteneder & Son, Theo., Philadelphia, Pa.
Kolesch & Co., New York.

Drawing Materials
Alteneder & Son, Theo., Philadelphia, Pa.
Kolesch & Co., New York.
Technical Supply Co., Scranton, Pa.

Drafting Machines
Universal Drafting Mach. Co., Cleveland, O.

Drilling Machines, Bench
American Watch Tool Co., Waltham, Mass.
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Ingersoll-Rand Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.
Rockford Drilling Mach. Co., Rockford, Ill.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Boiler
American Tool Works Co., Cin., O.

Drilling Machines, Boiler—*Continued.*
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Electric
Chicago Pneumatic Tool Co., Chicago, Ill.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.

Drilling Machines, Multiple Spindle
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Flather Planer Co., Mark, Nashua, N. H.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Hardinge Bros., Chicago, Ill.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.
Taylor & Fenn Co., Hartford, Ct.

Drilling Machines, Portable
Cincinnati Elec. Tool Co., Cin., O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.
Hisey-Wolf Mach. Co., Cin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial
American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Foundry Co., Jno. B., Cincinnati, O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Wormer Mchy. Co., C. C., Detroit, Mich.

Drilling Machines, Turret
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.

Drilling Machines, Upright—*Continued.*
Davis Machine Co., W. P., Rochester, N. Y.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, O.
Knight Machry. Co., W. B., St. Louis, Mo.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Mechanics Machine Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Taylor & Fenn Co., Hartford, Conn.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Ct.
Wiley & Russell Mfg. Co., Greenfield, Mass.
Wormer Mchry. Co., C. C., Detroit, Mich.

Drills, Center
Cleveland Twist Drill Co., Cleveland, O.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.

Drills, Rail
Foote-Burt Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Cleveland Twist Drill Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cin., O.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O

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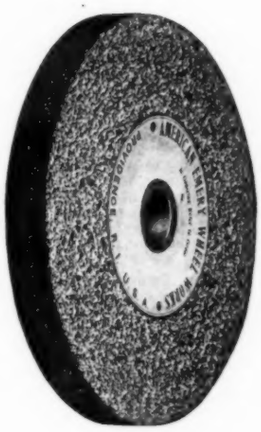

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will do *just this thing*, and that better results can be obtained in this way than where the workman is left to select a different wheel for every job he has to do. Time is lost in changing wheels and frequent mistakes are made in selection.

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American Emery Wheel Works,
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Starrett Hack Saws

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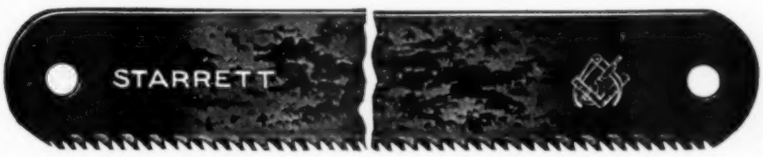

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Roth Bros. & Co., Chicago, Ill.
Triumph Electric Co., Cincin., O.
Wagner Elec. Mfg. Co., St. Louis, Mo.
Western Electric Co., Chicago, Ill.
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Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Cincinnati Electrical Tool Co., Cincinnati, O.
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Crescent Forgings Co., Oakmont, Pa.
Hisey-Wolf Mach. Co., Cincin., O.
Roth Bros. & Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.
Western Electric Co., Chicago, Ill.

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Albro-Clem Elevator Co., Philadelphia, Pa.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.
Morse, Williams & Co., Phila., Pa.

Emery Wheels

See Grinding Wheels.

Emery Wheel Dressers

American Emery Wheel Co., Providence, R. I.
Bay State Stamping Co., Worcester, Mass.
Desmond-Stephen Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

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Merritt & Co., Philadelphia, Pa.

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Crosby Steam Gage & Valve Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.

Engineers, Mechanical and Electrical

Crocker - Wheeler Co., Ampere, N. J.
Merritt, Jos., Hartford, Conn.
Seaver, John W., Cleveland, O.

Engines, Gas and Gasolene

Automatic Mach. Co., Bridgeport, Conn.

Engines, Gas and Gasolene —*Continued.*

Backus Water Motor Co., Newark, N. J.
Blaisdell Machinery Co., Bradford, Pa.
Grant Mfg. & Mach. Co., Bridgeport, Conn.

Engines, Motor

Franklin Mfg. Co., H. H., Syracuse, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

Engines, Steam

Sturtevant Co., B. F., Hyde Park, Mass.

Engraving Machinery

Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads

Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition, Machinery

Philadelphia Bourse, Phila., Pa.

Expanders, Tube

Nicholson & Co., W. H., Wilkes-Barre, Pa.

Eyelet Machinery

Manville Bros. Co., Waterbury, Conn.

Factory Equipment

Lyon Metallic Mfg. Co., Aurora, Ill.
Mfg. Equipment & Eng. Co., Boston, Mass.

Fans, Electric

Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sturtevant Co., B. F., Hyde Park, Mass.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust

Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., Phila., Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Files and Rasps

American Swiss File & Tool Co., New York.
Barnett Co., G. & H., Phila., Pa.
Carver File Co., Philadelphia, Pa.
Hammacher, Schlemmer & Co., New York.
Nash Co., Geo., New York.
Nicholson, File Co., Prov., R. I.
Reichhelm & Co., E. P., New York.
Simonds File Co., Fitchburg, Mass.

Filler, Iron

Clark Cast Steel Cement Co., Shelton, Conn.
Felton, Sibley & Co., Phila., Pa.

Filing Machines

Cochrane-Bly Co., Rochester, N. Y.
Henry & Wright Mfg. Co., Hartford, Conn.

Flexible Shafts

Chicago Flexible Shaft Co., Chicago, Ill.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.

Forges

Boynton & Plummer, Worcester, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Burke Machy. Co., Cleveland, O.
Ingersoll-Rand Co., New York.
Miner & Peck Mfg. Co., New Haven, Conn.
National Machinery Co., Tiffin, O.
Prentiss Tool & Supply Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Forgings, Drop

Bethlehem Steel Co., So. Bethlehem, Pa.
Billings & Spencer Co, Hartford, Conn.

Forgings, Drop —*Continued.*

Crescent Forgings Co., Oakmont, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Forgings, Hydraulic

Bethlehem Steel Co., So. Bethlehem, Pa.

Forgings, Steel

Bethlehem Steel Co., So. Bethlehem, Pa.
Cammel, Laird & Co., New York.
Crescent Forgings Co., Oakmont, Pa.
Tindel-Morris Co., Eddystone, Pa.

Foundry Furnishings

Adams Co., Dubuque, Iowa.
Goldschmidt Thermit Co., New York.
Ingersoll-Rand Co., New York.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Furnaces, Annealing and Tempering

American Gas Furnace Co., New York.
Chicago Flexible Shaft Co, Chicago, Ill.
Nash Company, Geo., New York.
Tate, Jones & Co., Pittsburg, Pa.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Enameling

American Gas Furnace Co., New York.

Furnaces, Gas

American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Obermayer Co., S., Cincinnati, O.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Melting

American Gas Furnace Co., New York.
Nash Company, Geo., New York.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Oil

Tate, Jones & Co., Pittsburg, Pa.

Furniture, Machine Shop

Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.

Manufacturing Equip. & Engineering

Co., Boston, Mass.
Merritt & Co., Philadelphia, Pa.
New Britain Mach. Co., New Britain, Conn.

Gages, Recording

Bristol Co., Waterbury, Conn.

Gages, Standard

Ames & Co., B. C., Waltham, Mass.
Athol Machine Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Grönkvist Drill Chuck Co., Jersey City, N. J.
Henry & Wright Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Wks., Jno. M., Gloucester City, N. J.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.
Wyke & Co., J., East Boston, Mass.

Gages, Steam

Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.

Gear Cutting Machinery

Adams Co., Dubuque, Iowa.
American Watch Tool Co., Waltham, Mass.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Bickford Drill & Tool Co., Cincinnati, O.

Gear Cutting Machinery —*Continued.*

Bilgram, Hugo, Philadelphia, Pa.
Brown & Sharpe Mfg. Co., Providence, R. I.
Clough, R. M., Tolland, Conn.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Morse, Williams & Co., Phila., Pa.
Newton Machine Tool Wks., Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Walcott & Wood Mach. Tool Co., Jackson, Mich.
Waltham Machine Works, Waltham, Mass.
Whiton Machine Co., D. E., New London, Conn.

Gear Testing Machinery

Gisholt Mach. Co., Madison, Wis.

Gears, Cut

Bilgram, Hugo, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., Chicago, Ill.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Davis, Rodney, Philadelphia, Pa.
Earle Gear & Machine Co., Philadelphia, Pa.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant Gear Wks., Boston, Mass.
Hardinge Bros., Chicago, Ill.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Horsburgh & Scott Co., The, Cleveland, Ohio.
Lea Equipment Co., New York.
Morse, Williams & Co., Phil., Pa.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Wks., Cleveland, O.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Wood Mach. Tool Co., Jackson, Mich.
Waterbury Gear Co., Waterbury, Conn.

Gears, Molded

Caldwell & Son Co., H. W., Chicago, Ill.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Horsburgh & Scott Co., Cleveland, Ohio.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.

Gears, Rawhide

Boston Gear Works, Norfolk Downs, Mass.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Earle Gear & Mach. Co., Philadelphia, Pa.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Grant Gear Works, Boston, Mass.
Horsburgh & Scott Co., Cleveland, O.
New Process Rawhide Co., Syracuse, N. Y.